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National Airspace System

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of Transportation
**Federal Aviation
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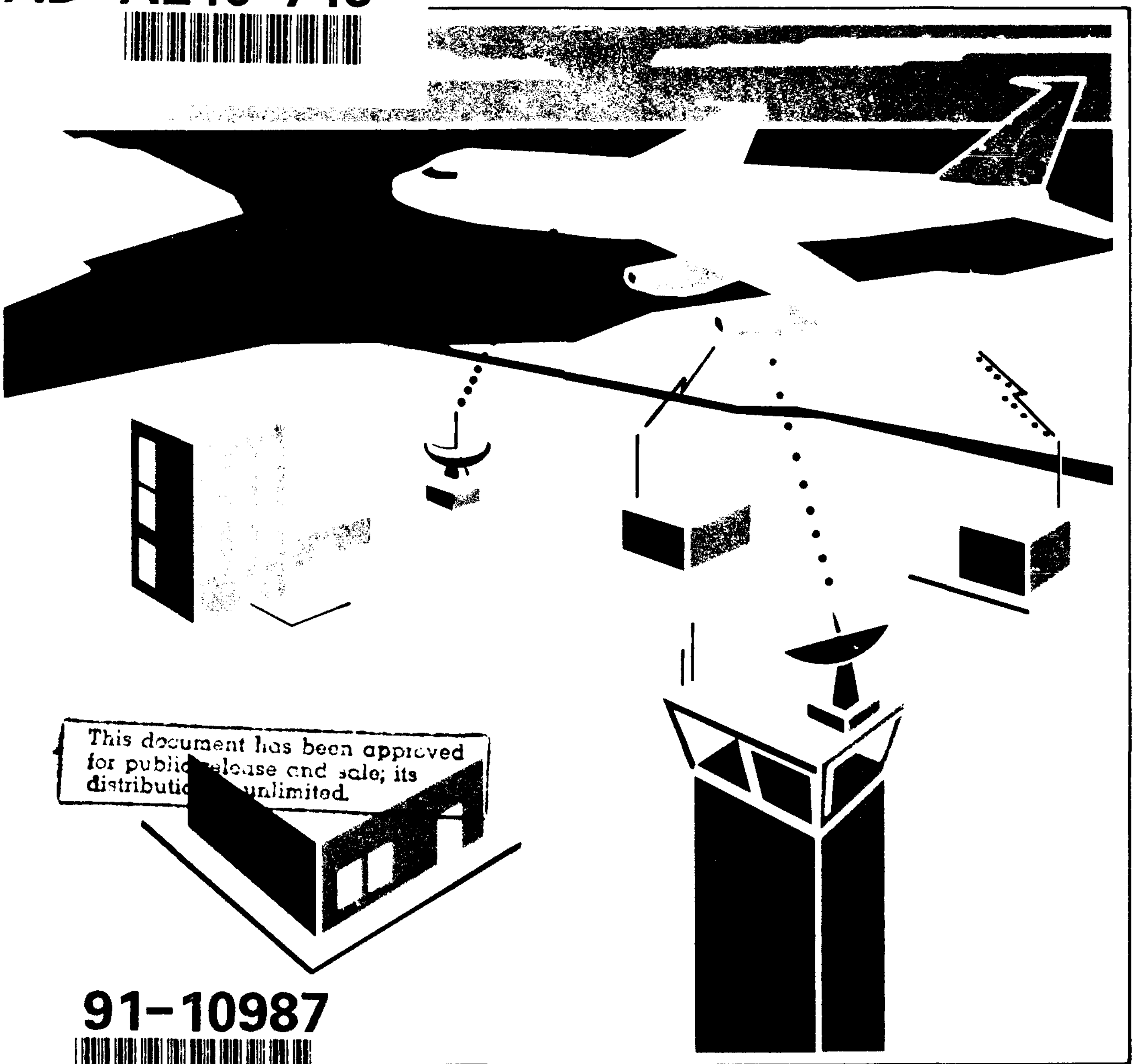
Navigation
Operational Concept
NAS-SR-134



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16. Abstract

A requirement for the National Airspace (NAS) is to provide for navigation, as identified in the NAS System Requirements Specification (NASSRS).

This operational concept is one of many high level documents that will, in total, describe the operation of the NAS when the projected upgrade is complete (i.e., "end state"). These documents will assist in linking the requirements specified in the NASSRS with the NAS design. This particular concept describes navigation as specified in paragraph 3.4 of the NASSRS, including paragraphs 3.4.1 Enroute Navigation; 3.4.2 Terminal Navigation; and 3.4.3 Visual Navigational Aids.

This concept, and the other seven operational concepts, will complete the description of the system requirements as described in the NASSRS.

The eight operational concepts are: Communications (NAS-SR-136); Navigation (NAS-SR-134); Monitoring (NAS-SR-133); Maintenance and Support (NAS-SR-137); System Effectiveness (NAS-SR-138); Air Defense (NAS-SR-135); Flight Planning (NAS-SR-131); and Traffic Control and Airspace Management (NAS-SR-132).

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1.0 INTRODUCTION

1.1 Background

The Federal Aviation Administration (FAA) is charged with providing for the regulation and promotion of civil aviation in order to best foster its development and safety, and to provide for the safe and efficient use of the airspace by both civil and military aircraft. Explicitly, the Administrator shall develop, modify, test, and evaluate systems, procedures, facilities, and devices defining their performance characteristics as needed. This effort is directed toward meeting the need for safe and efficient navigation and traffic control of all civil and military aircraft operating in a common civil/ military National Airspace System (NAS).

The National Airspace System System Requirements Specification (NASSRS), NAS-SR-1000, is the top level system requirements document for the NAS. The contents are a compilation of required operational capabilities for the NAS as envisioned to exist when the NAS Plan (Capital Investment Plan) is fully implemented. The primary intention of NAS-SR-1000 is for FAA internal use as a management tool in support of the NAS design, engineering, acquisition activities, and control of change to the NAS operational requirements.

This operational concept document has been developed using an established standard format and is consistent in structure with a series of operational concepts written about various sections of the NASSRS.

1.2 Objective

The objective of this operational concept document is to define the navigation system and services that will be provided in the future NAS. This is the total NAS viewed as a complete system as presently approved as of the date of this operational concept document. It is intended to be a descriptive document which provides FAA management and technical personnel and other user organizations with a clear understanding of the NAS navigation system. More specifically, the purpose of this document is to:

- Provide a common operational perspective across subsystems, operators, and users.

- Show the interrelationship between subsystems, facilities, information, and operators/users.

1.3 Scope

This operational concept for navigation describes the services provided as outlined in Section 3.4 of the NASSRS. The operations described are limited to those associated solely with navigation. Navigation services provided by certain types of specialists/controllers are also provided. The names assigned to these specialist/controller positions are based on the primary functions performed; although the names of the positions may not agree with those commonly used today or may change at a later date as the NAS evolves, the functions performed will not change.

This operational concept covers the following NAS navigation systems:

VHF Omnidirectional Range (VOR)

Distance Measuring Equipment (DME)
Tactical Air Navigation (TACAN)
Nondirectional Beacon (NDB)
Direction Finder (DF)
Long Range Navigation (LORAN-C)
Omega/Very Low Frequency (VLF)

The following specific paragraphs in the NASSRS Section 3.4 will be addressed in this operational concept:

3.4.1 En Route Navigation

- 3.4.1.A Provision & Support of Navigation Networks
- 3.4.1.B Compatibility with Approved User Equipment
- 3.4.1.C Information on Status & Location of Specific NAVAIDS

3.4.2 Terminal Navigation

- 3.4.2.A Navigation Capabilities at Specified Airports
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- 3.4.3.B Landing Area Alignment, Height Perception, Roll Guidance & Horizontal Reference
- 3.4.3.C Identification & Location of Airports
- 3.4.3.D Marking of Obstructions near Landing Areas
- 3.4.3.E Specialist Operation of Lighting Systems
- 3.4.3.F User Operation of Lighting Systems

1.4 Methodology

The methodology employed to develop this operational concept is similar to the methods and tools used for system development in that successive levels of the navigation functions are represented. This document starts with the overall concept and proceeds to its most elemental levels of support, diagrammatic tools, and techniques that constitute navigation within the NAS. These analytical tools are:

1. Operational Block Diagram/Description. The operational block diagram illustrates the connectivity between major elements of the NAS, i.e., processors, specialists/controllers, and the user for those elements that support the service. The operational block diagram in this operational concept is extracted from the overall NAS operational block diagram. Principal features of the operational block diagram/description include the following:

   a. Each specialist/controller is indicated by a number. This number remains the same in every NASSRS operational concept.

   b. Dotted lines segregate facilities.

c. Solid lines show digital data flow, and voice data flow is also shown. Each type of data flow is appropriately labeled.

d. The blocks within each facility are the major processors.

2. Operational Flow Diagrams/Descriptions. An operational flow diagram and associated description for each specialist provides details about the inputs, processes, outputs, and interfaces for each operator; thus, the operational flow diagram provides an expansion of each element of the NAS shown in the navigation block diagram (fig 2-2). Operational flow diagrams are used to functionally describe the products and services of individual specialists.

3. Operational Sequence Diagrams/Descriptions. The operational sequence diagram and associated description show a typical sequence of steps taken by operators/users in supporting navigation operations. Principal features of an operation sequence diagram include the following:

   a. Users, specialists, and computer systems involved with providing navigation functions are listed along the vertical axis. When required for clarity, other FAA facilities may also be listed on the vertical axis.

   b. The horizontal axis represents time. Sequential events or functions performed are indicated within separate boxes. Events which may occur simultaneously or near-simultaneously are shown vertically.

   c. Decision points or points where alternate paths may be followed are indicated by a diamond shape.

   d Circles are connectors and indicate exit to, or entry from, another diagram. Circles with a lower case alphabetic character reference an operator function described in the figure listed below the circle. Circles connect either to another sheet of the same diagram or to another diagram; the relevant figure number is listed underneath if connection is to a different diagram. Thus, the relationship between operator/user interactions and relevant NAS subsystems can be depicted.

1.5 Document Organization

The remainder of this document is organized in the following manner. Section 2 is the main body of the document and is divided into six subsections. Section 2.1 provides an overview description of the navigation functions and introduces (identifies) the personnel complement and physical entities (facilities and computer systems), which provide the required support. Section 2.2 describes the information used to provide navigation support. Section 2.3 provides descriptions of the functional decomposition of navigation services. (Sections 2.1, 2.2, and 2.3 reference related NASSRS 3.4 subsystems.) Section 2.4 presents correlation requirements for navigation support. Section 2.5 provides a sequence of interactions between system and personnel entities during the planning and the implementational phases of navigation services. Section 2.6 describes navigation operational scenarios.

2.0 NAVIGATION OPERATIONS

2.1 Support

The FAA is required by the Federal Aviation Regulations (FAR) to provide navigational services to users, which is described in Section 3.4 of the NASSRS. Air navigational services are provided by earth-referenced navigational aids such as:

- Very High Frequency Omnidirectional Range (VOR)
- Tactical Air Navigation (TACAN)
- VOR collocated with a TACAN (VORTAC)
- Distance Measuring Equipment (DME)
- Non-Directional Beacon (NDB)
- Long Range Navigation (LORAN)
- Other Facilities (e.g., Omega, GPS)

Nonprecision navigational aids used for landing in the terminal area include VOR, TACAN, NDB, and LORAN-C. Precision navigational aids are the Instrument Landing System (ILS), and the Microwave Landing System (MLS).

Visual navigational aids used in guiding pilots to airports and runways during day and night include:

- Visual Approach Slope Indicator (VASI)
- Precision Approach Light System (ALSF-2/MALSR)
- Precision Approach Path Indicator (PAPI)
- Runway End Identifier Lights (REIL)
- Omnidirectional Approach Light System (ODALS)
- Runway edge light systems
- Runway lighting (Centerline & Touchdown Zone)
- Airport rotating beacon

2.1.1 Positions/Systems/Functions

Figure 2-1 presents an overview of NAS/user interfaces for navigational services and displays the NAS facilities and systems involved. Figure 2-2 is an operational block diagram that shows the interrelationships among equipment, facilities, operators/users, and information necessary to support navigational services. The following paragraphs briefly summarize navigational services at each position displayed in Figure 2-2.

The functions provided by each specialist position and a description of each follows. Included with each description is a reference to the current procedures manual for the position and to those NAS projects that are most likely to affect how the specialist provides the service.

Position 5: DF Specialist
Functions: Provides location and navigational information to pilots requesting assistance.
Description: A specialist in the AFSS who provides bearing and headings using the VHF communications signal to lost or disoriented pilots using DF equipment that locates the aircraft's VHF transmitter. This position is usually combined with the Inflight Specialist position.

Procedures: FAA Handbook 7110.10J, Flight Services
Projects: Capital Investment Plan, Chapter 2, Section 4 - Ground-to-Air; Project 24-11 Direction Finder (DF); Chapter 4, Section 4 - Ground-to-Air, Project 44-31, DF Replacement.

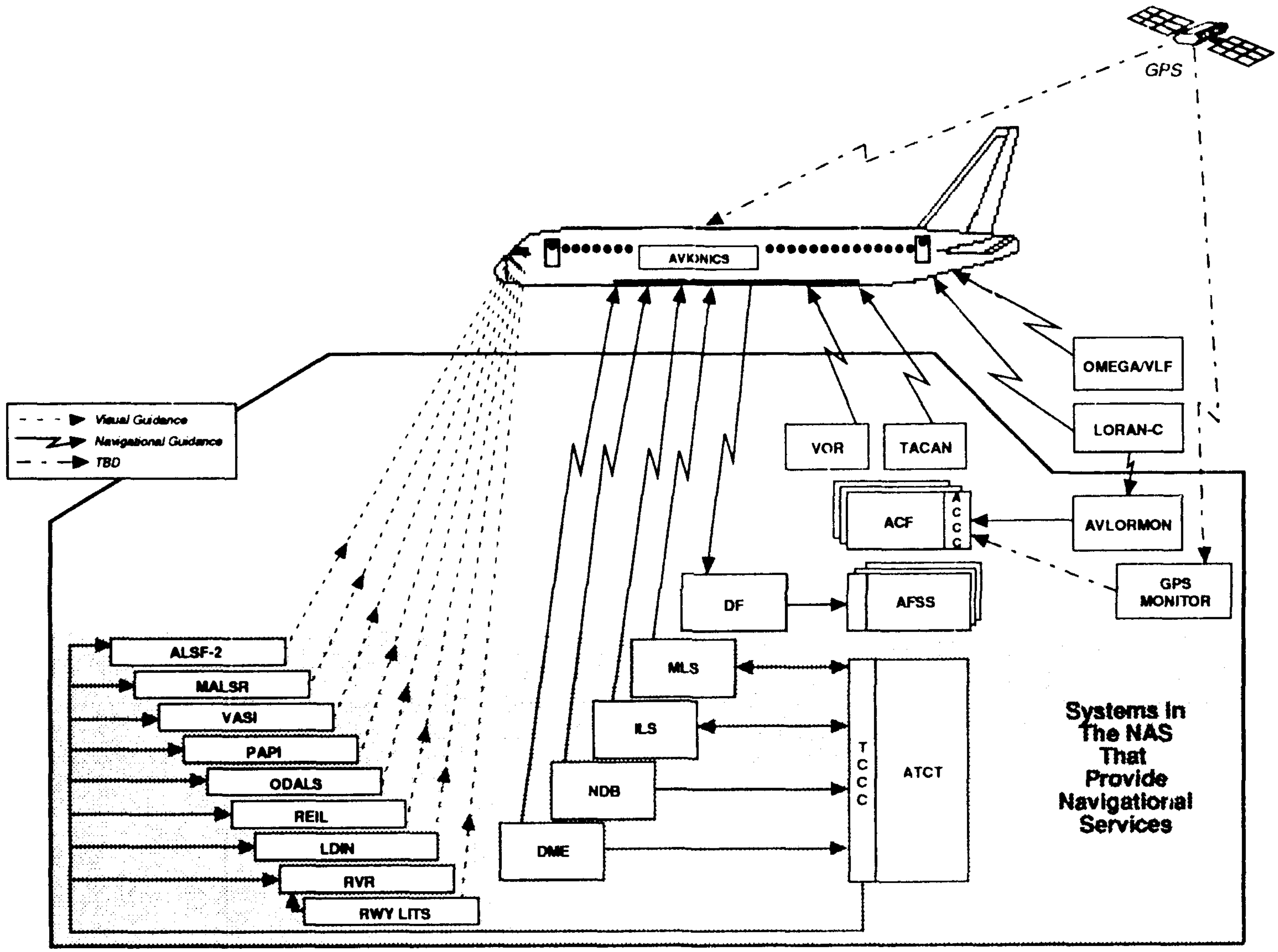

FIGURE 2-1
OVERVIEW OF NAS/USER INTERFACES
FOR NAVIGATION

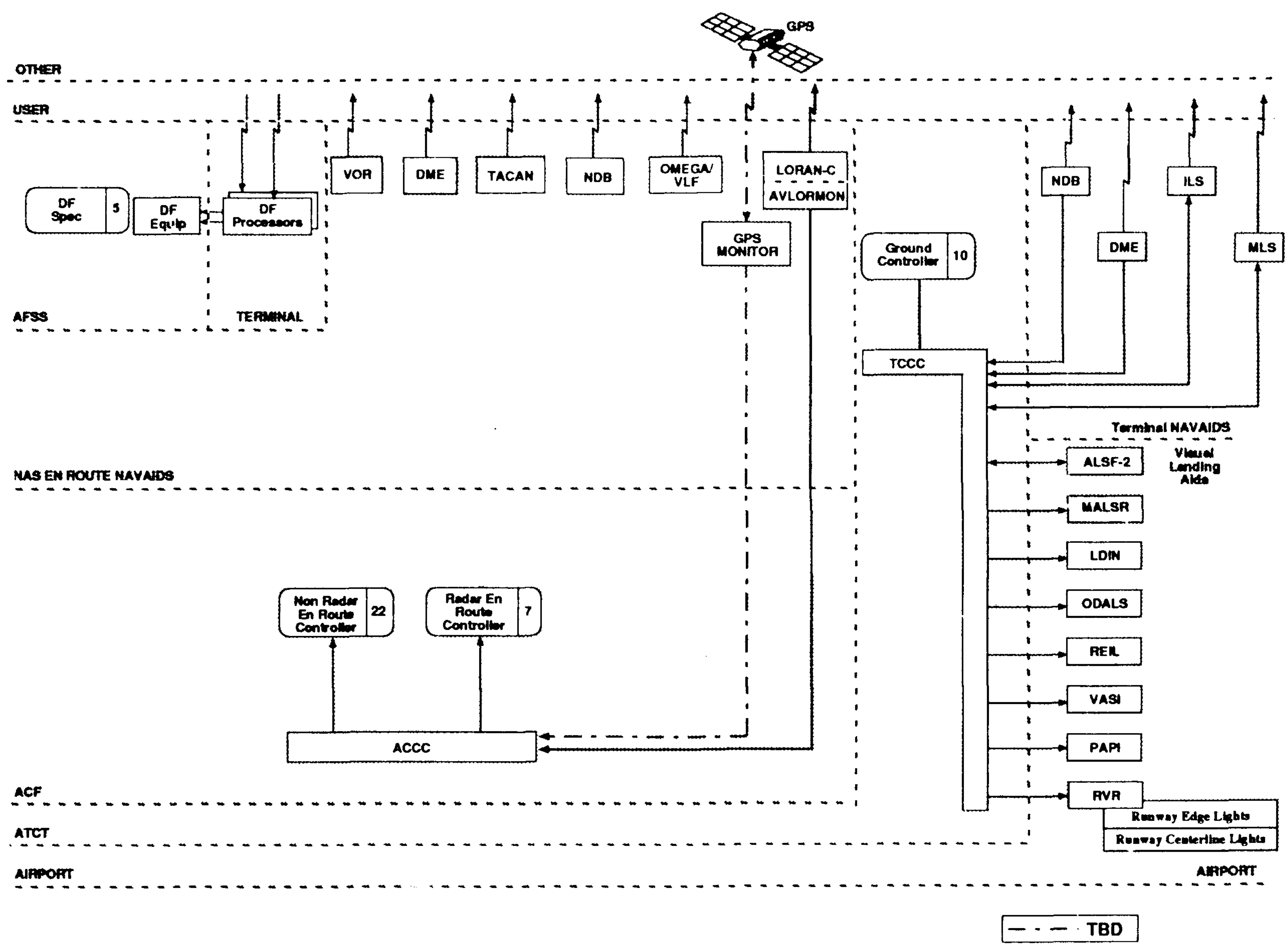

FIGURE 2-2
NAVIGATION OPERATIONAL
BLOCK DIAGRAM

Position: 7 and 22 Radar En Route and Non-Radar En Route Controllers
Function: En route air traffic control
Description: Receive and forward NAVAID status to pilots.

Procedures: FAA Handbook 7110.65F, Air Traffic Control; 7110.83 Oceanic Air Traffic Control

Projects: Capital Investment Plan, Chapter 2, Project 21-15, Area Control Facilities (ACF); Section 4: Project 24-17 LORAN-C Systems; Chapter 4 - Section 4: Project 44-35, LORAN-C Monitors

Positions 9 & 10: ATCT Controllers
Function: Local and Ground Controllers
Description: Specialist in an ATCT that, in addition to other duties, controls airfield lighting such as Precision Approach Lighting Systems (ALSF 2/MALSR), Lead-In Lighting Systems (LDIN), Omnidirectional Approach Lighting Systems (ODALS), Runway-End Identifier Lights (REILS), Visual Approach Slope Indicators (VASI), Precision Approach Path Indicators (PAPI), and the Runway Visual Range (RVR), Runway Edge Lights, High Intensity Runway Lights (HIRL), Touchdown Zone Lights (TDZL), Medium Intensity Runway Lights (MIRL), High Speed Turnoff Lights, Taxiway Lights, Obstruction Lights, and the Rotating Beacon.

Procedures: FAA Handbook 7110.65F, Air Traffic Control

Projects: Capital Investment Plan, Chapter 2, Section 4: Project 24-07, Microwave Landing System (MLS); Project 24-08, Runway Visual Range (RVR); Project 24-09, Visual Navaids; Project 24-10, Approach Lighting System Improvement Program (ALSIP); Chapter 3: Section 4 - Ground-to-Air: Project 34-04, Establish Locator Outer Markers (LOM); Project 34-06, Instrument Landing System (ILS); Project 34-07, Microwave Landing System (MLS); Project 34-08 Runway Visual Range (RVR) Establishment; Project 34-09 Establish Visual Navaids for New Qualifiers; Chapter 4 - Section 4 - Ground-to-Air: Project 44-20, AN/GRN-27 Instrument Landing System (ILS) Replacement; Project 44-21, Wilcox CAT II/III ILS Replacement; Project 44-22, Replace Mark 1A, 1B, and 1C ILS; Project 44-24, ILS and Visual Navaids Engineering and Sparing; Project 44-29, Runway Visual Range (RVR) Replacement; Project 44-33, Approach Lighting System Improvement (ALSIP) Continuation

2.2 Navigation

The NAS provides navigational aids that enable users to safely and efficiently navigate from take-off to landing. These navigational aids assist pilots in both the en route and terminal environments under all weather conditions.

2.2.1 En Route Navigation

The NAS provides en route navigational aids that enable users to define and use routes of flight and determine aircraft position. The requirements for en route navigation aids are described in paragraph 3.4.1 of the NASSRS.

The NAS supports the development and certification of modern systems of aircraft navigation which meet or exceed current standards and are not currently part of the NAS navigational networks.

Additionally, the NAS navigational network is capable of rapid shutdown or restricted operation in accordance with the military command/FAA supplemental agreements to support national defense requirements.

2.2.1.1 Provision and Support of Navigation Networks

The NAS provides a primary navigational network and accommodates supplemental navigation systems to meet user requirements. A supplemental air navigation system is an approved navigation system that can be used in controlled airspace of the NAS in conjunction with a sole means navigation system. Sole means navigation system is an approved navigation system that can be used for specific phases of air navigation in controlled airspace without the need for any other navigation system.

The NAS provides navigational information in such a manner that a pilot can determine his position by bearing and range from a predetermined aeronautical fix as well as his position relative to a predetermined flight path.

NAS-provided navigational aids that provide guidance in terms of rho/theta coordinates are referenced in the following manner: the rho coordinate is referenced to the location of the navigational aids, and the theta coordinate is referenced to magnetic north. The following navigation systems are utilized in the en route portion of the NAS and are compatible with NAS-approved user equipment.

VHF Omni-Directional Range (VOR)

The NAS primary navigational network is made up of a series of VHF Omnidirectional Ranges (VOR) spaced an average of 80 NM apart. The VOR provides a very high frequency (VHF) bearing reference signal in such a way as to define distinct airways which are radially disbursed around the VOR. The avionics, when tuned to the VOR signal, will detect whether the aircraft is on the selected radial or right or left of course. The VOR can be used as a sole means of air navigation. Additionally, the VOR system has sufficient capacity to provide bearing information to an unlimited number of aircraft.

Distance Measuring Equipment

The distance measuring equipment (DME) is a Ultra High Frequency (UHF) receiver/transmitter (transponder). The DME operates by receiving a signal sent by an aircraft to interrogate the DME. The DME responds with a signal to the aircraft. The aircraft avionics then calculates the distance between the aircraft and the DME by using the measured time period between the transmission of the interrogation and the reception of the response.

When collocated with a VOR (VOR/DME) this facility can provide a pilot with both azimuth and distance information. DME can provide distance information to at least 100 aircraft per navigational system.

Tactical Air Navigation (TACAN)

The TACAN is a UHF transmitter/receiver system which provides both azimuth and distance measurement information to the pilot electronically via the aircraft avionics. It provides a UHF bearing reference signal that appears similar to the VHF signal provided by the VOR. TACANs are often collocated with VORs which enable military pilots to fly the same radials that make up the Federal airway/Jet route system. TACANs may be used as a sole means of navigation by military pilots.

VOR/TACAN (VORTAC)

Facilities at which VOR and TACAN are collocated are called VORTACs. These airways guidance facilities (VORs, VOR/DMEs, and VORTACs) are strategically located to form a network of airways that provide national en route navigational guidance to users of the NAS. Each airway is based on a centerline that extends from one navigational aid or intersection to another navigational aid (or through several navigation aids or intersections) specified for that airway.

The NAS provides en route coverage using these navigational aids from 2,000 feet AGL up to and including 60,000 feet above MSL for all NAS designated controlled airspace, unless specifically designated otherwise. Table 2-1 describes the range and altitude limits for these NAVAIDS.

Table 2-1 NAVAID'S Standard Service Volume

Class Designator	Range Limits	Altitude Limits
Terminal (T) Facility	25 Nautical Miles (Nm)	1,000 AGL - 12,000 AGL
Low Altitude (L) Facility	40 Nm	1,000 AGL - 18,000 AGL
High Altitude (H) Facility	40 Nm 100 Nm 130 Nm 100 Nm	1,000 AGL - 14,500 AGL 14,500 - 18,000 AGL 18,000 - 45,000 AGL 45,000 - 60,000 AGL

Oceanic Navigation

The NAS-approved en route navigational equipment designated for use in oceanic areas between the altitudes of FL 275 and FL 400 for normal density traffic supports route widths of less than 60 NM. Two NAS approved en route navigational aids used in oceanic airspace are LORAN-C and Omega.

Long Range Navigation (LORAN-C)

LORAN-C is a low frequency, hyperbolic navigation system which is owned and operated by the U.S. Coast Guard (USCG). LORAN-C is based upon measurement of the difference in time of arrival of pulses of radio-frequency energy radiated by a group, or chain of transmitters which are separated by hundreds of miles. LORAN-C provides the user, who uses an adequate receiver, with predictable accuracy of 0.25 nautical miles or better. LORAN-C signals are used to provide en route, terminal, and nonprecision approach capabilities to aviation users. LORAN-C is one of two civil radionavigation systems approved for oceanic en route navigation.

OMEGA

The other civil radionavigational system approved for use in oceanic as well as domestic airspace is the OMEGA system. OMEGA is a network of eight transmitting stations located throughout the world to provide worldwide signal coverage. These stations transmit in the Very Low Frequency (VLF) band. Because of low power and frequency, the signals are receivable to ranges of thousands of miles. The stations are located in Norway, Liberia, Hawaii (USA), North Dakota (USA), Argentina, Australia, and Japan. The OMEGA navigation network is capable of providing consistent fixing information to an accuracy of plus or minus 2 NM depending upon the level of sophistication of the receiver/processing system.

The U.S. Navy also operates a communications system in the VLF band. The stations are located worldwide and transmit at powers of 500-1000 kW. Some airborne OMEGA receivers have the capability to receive and process these VLF signals for navigation in addition to OMEGA signals. The VLF stations generally used for navigation are located in Australia, Japan, England, Hawaii and in the U.S. (Maine, Washington and Maryland).

Although the Navy does not object to the use of the VLF communications signals for navigation, the system is not dedicated to navigation. Signal format, transmission, and other parameters of the VLF system are subject to change at the Navy's discretion. The VLF communications stations are individually shut down for scheduled maintenance for a few hours each week. Regular NOTAM service regarding the VLF system or station status is not available.

The FAA has recognized OMEGA and OMEGA/VLF systems as an additional means of en route IFR navigation in the conterminous United States and Alaska when approved in accordance with FAA guidance information.

Global Positioning System

The Global Positioning System (GPS) is a spaced-based positioning, velocity, and time transfer system developed by the DoD. This system provides highly accurate position and velocity information, and precise time, on a continuous global basis, to an unlimited number of properly equipped users. The GPS system, using 21 operational satellites, with three operational spares, orbiting the earth in six orbital planes, will be unaffected by weather, and will provide a worldwide common grid reference system. The GPS concept is predicated upon accurate and continuous knowledge of the spatial position of each satellite in the system with respect to time and distance from transmitting satellites to the user. The GPS receiver automatically selects appropriate signals from the satellites in view and translates these into a three-dimensional position, velocity, and time.

Currently not part of the NAS, GPS has the potential for worldwide (domestic and oceanic) use. The DoD will declare the GPS constellation fully operational when 21 operational (Block II) satellites are functioning in their assigned orbits. This is expected to occur in 1993.

Domestic Airspace

The NAS-approved navigational aids designated for use in domestic areas between the altitudes of 500 feet and FL 600 for normal and high-density traffic support nominal route widths of 8 NM or less.

The current network of federal airways is divided into two route systems: the Victor Airway System and the Jet Route System. The Victor Airway System consists of airways designated from 1,200 feet above the surface (or in some instances higher) up to but not including 18,000 feet MSL. Victor airways have a nominal route width of 8 NM (4 NM either side of the route centerline). However, greater route widths are used in low traffic density areas, remote areas, and on most of the high-altitude route structure due to the increased spacing between NAVAIDS.

For high altitude en route navigation, j . routes are established from FL 180 to FL 450. Parts of the high-altitude route structure have a distance between VOR facilities resulting in nominal route widths up to 20 NM. Due to VOR navigational service limitation, the highest a jet route can used is FL 450; above that, up to FL 600 there is no route structure. Therefore, random routes based on others types of navigational aids are used.

Even though Victor Airways and Jet Routes are based on VOR/DME, or VORTACs, other on-board navigational systems may be used to navigate on these routes. Systems such as TACAN, OMEGA, LORAN-C, and GPS when declared operational, allow pilots to navigate along these routes as well as using VOR.

Remote Areas

NAS approved en route navigational aids designated for use in remote areas between the altitudes of 500 feet and FL 600 for normal density traffic support nominal route widths of 20 NM or less. Remote areas are defined as regions which do not meet the requirements for installation of VOR/DME service, or where it is impractical to install this system. Many areas (such as Alaska, and some offshore locations) cannot be served easily or at all by VOR/DME. Navigational aids such as Non-Directional Beacons (NDB), LORAN-C, and GPS when declared operational, are used in these areas.

Nondirectional Beacon (NDB)

Another type of supplemental navigational facility is the Non-Directional Beacon (NDB). The NDB is a short distance air navigation system. The ground component provides properly equipped aircraft with bearing and identification referenced to the selected ground complex. The system provides navigation signals to all civil and military aviation for the safe and efficient conduct of aircraft operations, exercise of air traffic control, and use of airspace.

The NDB provides a continuous radio broadcast to enable a pilot to obtain a bearing on a specific geographic fix at which the NDB is located. It can be used for en route navigation or to provide guidance for the approach to an airport. It also can be used in conjunction with an ILS to perform instrument approaches. In this case the NDB is collocated with the outer marker and is referred to as a Locator Outer Marker (LOM).

Direction Finder

The direction finder is a ground-based VHF radio receiver, processor, and display system which is part of the navigation facilities. The DF receives a radio signal which is transmitted by the lost aircraft over a standard VHF transceiver and determines the aircraft's bearing relative to the DF receiver site. The bearing information is put into a digital format and sent to a dedicated DF processor in the AFSS facility. The processor calculates the transmitting aircrafts' position from multiple DF receiver site bearings. Calculated aircraft position is displayed to the specialist. The DF contains

a data base of navigation aids, airports, and obstruction locations for display to the specialist.

Rotorcraft Operation

NAS-approved en route navigational aids designated for limited use applications, such as rotorcraft, between the altitudes of 500 feet and 5000 feet for low density traffic (off-shore) support nominal route widths of 8 NM or less. Additionally, these en route navigational aids also support rotorcraft operations between the altitudes of 500 feet and 3000 feet for high-density traffic with nominal route widths of 4 NM or less.

2.2.1.2 Compatibility with Approved User Equipment

The VOR is the primary navigational aid used in both the en route and terminal areas of the NAS. The VOR navigational network is referenced to NAS-approved radionavigation aids, the magnetic compass, geographic coordinates, and navigation charts. The VOR has sufficient update rate of position and deviation from a selected course to allow coupled autopilot operation.

En route navigation aids can also be used in terminal areas so that the same airborne avionics are used for both en route and terminal navigation. For example, the DME is usually collocated with a VOR, but it can be collocated with a nondirectional beacon (NDB) or an instrument landing system (ILS) as part of a landing facility.

Additional avionics, including multi sensor systems, can be added which will enable the user to define his own route between any two arbitrarily selected geographic points. This method of navigation is known as area navigation (RNAV). RNAV permits navigation via a selected course to a predefined point without having to fly directly toward or away from a navigation aid.

2.2.1.3 Information on Status and Location of Specific NAVAIDS

Every primary NAS-provided navigational aid transmits an identification that is unique within that navigational aid's area of signal coverage. Transmittal of the identification is discontinued whenever the operation of the navigational aid has been discontinued or maintenance or testing is being performed.

The navigational system has a capability of recovering from a temporary loss of signal in such a manner that the signal transmitted to users provides accurate navigational information without the need for complete resetting. The NAS discontinues, within 10 seconds, the operation of NAS-provided navigational aids whose performance is outside of the acceptable parameters. The NAS alerts users and specialists to any known failures of navigational aids that may affect operations within the NAS airspace.

The NAS provides for monitoring of signals from certain supplemental navigational systems. The NAS informs specialists and users of the status of supplemental systems and provides correction values, if required, to improve navigational accuracy. For example, the LORAN-C Aviation Monitor (AVLORMON) monitors the LORAN-C navigation signals. The AVLORMON measures and stores LORAN-C parameters for the purpose of determining long term signal characteristics and calibration values.

2.2.2 Terminal Navigation

The NAS provides a system that allows users to navigate to and from airports. Navigation guidance is provided in the lateral and vertical planes and a means is provided to indicate distance information. Whenever possible, these navigational aids are similar to those provided in the en route structure so that much of the same airborne equipment can be used for both terminal and en route navigation.

The NAS provides terminal navigation information in such a manner that a pilot can determine his position by bearing and range from a predetermined aeronautical fix. As in en route navigation, NAS-provided terminal navigational aids provide guidance in terms of rho/theta coordinates. An example of this type of navigational aid used in the terminal environment is the VOR/DME.

NAS-approved terminal navigational aids designated for use between the altitudes of 500 feet and FL 180 for high density traffic support route widths of 4 NM or less. The NAS provides approach information in a manner that a pilot can determine his position relative to a predetermined flight path.

Additionally, the navigational information provided by the terminal systems are free from unresolved ambiguities of operational significance. The terminal and approach navigation systems have a capability of recovering from a temporary loss of signal in such a manner that the signal transmitted to users provides accurate navigational information without the need for complete resetting.

The requirements for terminal navigation aids are described in paragraph 3.4.2 of the NASSRS.

2.2.2.1 Navigational Capabilities at Specified Airports

The NAS provides navigational capabilities that give users approach, landing, and departure information. Additionally, continuous distance measuring, vertical guidance (glide slope), and azimuth guidance information are also provided as part of precision instrument approaches.

The first such function provides electronic approach, landing, and in some cases, rollout, missed approach, or departure guidance. This is accomplished by the transmission of radio signals which are received and interpreted by the avionics in the aircraft. The avionics are capable of determining the position of the aircraft relative to a specified approach path. The two systems that perform this precision instrument approach function are the Instrument Landing System (ILS) and the Microwave Landing System (MLS). The ILS provides the pilot with straight-in approach path (azimuth), distance, and elevation. The MLS provides the flexibility of using curved approaches as well as providing a choice of multiple approach paths and glidepath angles of up to 15 degrees. Additionally, the MLS (and ILS) provides back azimuth which provides lateral guidance for missed approach and departure navigation.

Precision Approach Information

Primary terminal navigational aids and all precision landing systems have a sufficient update rate of both position and deviation from a selected course to allow coupled autopilot operation. Precision landing systems have the capacity to provide course and glide slope information to an unlimited number of aircraft simultaneously. Designated terminal navigation and precision landing systems which provide distance information are capable of providing distance information simultaneously to at least 100 aircraft per facility.

Designated precision final approach signal coverage and guidance capability is provided in a sector defined by at least plus or minus 40 degrees laterally from the specified final approach path and from 0.9 degrees to 15 degrees above the horizon and within 20 NM from the landing area.

A single accuracy standard is desirable for all precision approaches, regardless of landing minimums. This accuracy standard at the runway threshold is at least plus or minus 20 feet laterally, plus or minus 2 feet vertically, and plus or minus 100 feet longitudinally.

Instrument Landing System (ILS)

The ILS is an electronic final approach and landing aid used for precision instrument approaches to certain airports. The ground equipment consists of two highly directional transmitting systems and, along the approach, three (or fewer) marker beacons. The directional transmitters are known as the localizer and glide slope transmitters. The ILS provides three functional items of information: course guidance, range from marker beacons or DME, and elevation information.

The localizer provides course guidance throughout the descent path to the runway threshold from a distance of 18 NM from the antenna between an altitude of 1,000 feet above the highest terrain along the course line and 4,500 feet above the elevation of the antenna site.

The glide slope transmits a glide path beam 1.4 degrees wide. The signal provides descent information for navigation down to the lowest authorized decision height (DH) specified in the approved ILS approach procedure.

Ordinarily, there are two marker beacons associated with an ILS, the outer (OM) and middle marker (MM). Locations with a Category II and III ILS also have an inner marker (IM). The OM normally indicates a position at which an aircraft at the appropriate altitude on the localizer course will intercept the ILS glide path. The MM indicates a position approximately 3,500 feet from the landing threshold. This is also the position where an aircraft on the glide path will be at an altitude of approximately 200 feet above the elevation of the touchdown zone. The IM indicates a point at which an aircraft on the glide path between the MM and the landing threshold is at an altitude of approximately 100 feet above the touchdown zone. At some locations distance measuring equipment (DME) is installed to be used in lieu of the outer marker, as a back course final approach fix, or to establish other fixes on the localizer as necessary.

Instrument Landing Systems are categorized as Category I, Category II, or Category III. Each category has a minimum decision height (DH) and runway visual range (RVR) for a properly equipped and staffed aircraft to land at an airport during instrument meteorological conditions (IMC).

NAS-approved precision landing systems designated for Category I approaches provide guidance between the altitudes of 100 to 3000 feet above the surface, and support lateral accuracies of plus or minus 30 feet and vertical accuracies of plus or minus 10 feet, at 100 feet above the surface. Category II approaches provide guidance between the altitudes of 50 to 3000 feet above the surface and supports lateral accuracies of plus or minus 15 feet and vertical accuracies of plus or minus 4 feet, at 50 feet above the surface. For Category III approaches the guidance between the surface and 3000 feet above the surface and supports lateral accuracies of plus or minus 1.2 feet, at 8 feet above the surface. In this concept all accuracies are at the 95 percentile probability level.

Microwave Landing System (MLS)

Like the ILS, the MLS will provide precision azimuth and elevation guidance. The MLS is divided into five functions: approach azimuth, back azimuth, approach elevation, range, and data communications.

The azimuth station is analogous to an ILS localizer. It performs the approach azimuth and data communications functions. In addition to providing azimuth navigation guidance, the station transmits basic data which consists of information associated directly with the operation of the landing system, as well as advisory data on the performance of ground equipment.

The elevation station, which provides approach elevation, is analogous to the glide slope facility of the ILS, except that the elevation station provides for a selection of glide slope angles by the pilot up to 15 degrees.

The precision DME (DME/P) will provide continuous range information in place of the station passage indications provided by the marker beacons of the ILS.

Most importantly, the MLS allows multiple-curved and segmented approaches as well as selectable glide slope angles. The standard MLS configuration can be expanded to provide back azimuth for lateral guidance for missed approach and departure navigation and auxiliary data transmissions which provide additional data.

Nonprecision Approach Information

The NAS provides for nonprecision approaches, between the altitudes of 250 feet and 3000 feet above the surface, to be conducted with 0.6 NM total system use lateral accuracy, of which the NAS equipment contributes less than 0.30 NM error at the missed approach point. This total system use accuracy allows for flight technical error of up to 0.5 NM in the approach area.

Visual approach path guidance for nonprecision runway approaches is available from a family of approach path indicators. The Omnidirectional Approach Lighting Systems (ODALS), Precision Approach Path Indicator (PAPI) or Visual Approach Slope Indicator (VASI) are used for approach path guidance.

In those situations along either a straight or curved approach path where special problems exist, such as hazardous terrain, obstructions, or noise abatement restrictions, the Lead-in Lighting system (LDIN) will be used.

2.2.2.2 Navigational Capabilities Available Continuously

The navigational capabilities of the NAS are available to users on a continuous basis under all weather conditions. In order to ensure that a basic ATC system remains in operation despite an area wide or catastrophic commercial power failure, key equipment and certain airports have been designated to provide a network of facilities whose operational capability can be utilized independent of any commercial power supply.

In addition to those facilities comprising the basic ATC system, the following approach and lighting aids have been included in this program for a selected runway.

- ILS (Localizer, Glide Slope, Compass Locator, Inner, Middle and Outer Markers)
- MLS
- Wind Measuring Capability
- Approach Light Systems
- Ceiling Measuring Capability
- Touchdown Zone Lighting
- Centerline Lighting
- Runway Visual Range
- Taxiway Lighting
- Apron Lights

2.2.2.3 Monitoring and Alerts on Navigational Status and Performance

The NAS provides monitoring of navigational information for status and operational performance parameters and alerts users/specialists when there is a change in status.

The NAS provides monitoring of signals from certain supplemental navigational systems such as LORAN-C. The AVLORMON monitors LORAN-C navigation signals to determine correction values for nonprecision approach use in the NAS. The AVLORMON measures and stores LORAN-C parameters for the purpose of determining seasonal signal characteristics and correction values. These correction values are used to improve navigational accuracy for the LORAN-C user and are included for use with NAS approach publications and charts each 56 days.

Although not a navigational system, the VOR test (VOT) is a VHF transmitter which is part of the navigation facilities within the NAS. It is used independently of the VOR network to provide a means by which a pilot can perform a VOR receiver check to verify that the VOR receiver is operating within established limits. Located at selected airports, VOTs normally are used to perform receiver checks prior to takeoff.

The NAS discontinues, within 10 seconds, the operation of NAS-provided navigational aids whose performance is outside of the acceptable parameters. The NAS also alerts the users and specialists to any known failures of navigational aids that may affect operations within the NAS airspace.

The location of each NAS-provided rho/theta type navigational aid is provided in geographic coordinates (lat/long). Additionally, the following navigational facilities transmit an identification code that is unique within its area of signal coverage: ILS, LORAN-C, MLS, NDB, TACAN, VOR, DME, and VOT. During periods of routine or emergency maintenance, coded identification (or code and voice, where applicable) is removed from certain FAA NAVAIDS. Removal of identification serves as a warning to pilots that the facility is officially off the air for tune-up or repair and may be unreliable even though intermittent or constant signals are received. During periods of maintenance, VHF omniranges may radiate a T-E-S-T Morse code (- . ... -) or the code may be removed.

2.2.3 Visual Aids to Navigation

Because of commercial and residential expansion around airport areas, determining the location and identification of the airport has become more difficult for pilots of aircraft not equipped with electronic landing aids. To aid all users during times of reduced visibility or darkness, visual aids to navigation are provided in the NAS. These devices include, but are not limited to, lighting, visual decent guidance devices, airport location aids,

and standardized airport marking aids. The requirements for visual navigation aids are described in paragraph 3.4.3 of the NASSRS.

2.2.3.1 Curved, Offset & Straight-In Guidance for Visual & Nonprecision Approaches

The NAS provides visual aids that provide for curved, offset, and straight-in guidance as dictated by individual airport/terrain characteristics for precision, nonprecision and visual approaches.

Approach Lighting Systems

The precision approach lighting systems consist of configurations of signal lights that provide the pilot visual information on runway alignment, height perception, roll guidance, and horizontal references to precision approach runways. Approach lights are normally installed on the ILS/MLS runway to provide a means for transition from instrument to visual flight.

This function is provided by a series of standard lighting systems: the Approach Lighting System with Sequenced Flashers (ALSF-2) and the Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR) for precision runways.

The ALSF-2 consists of both steady burning and sequenced flashing lamps. A light bar containing five equally spaced white lights is located at each 100-foot interval, starting 100 feet from the runway threshold and extends out to 2,400 feet. In addition to steady burning lights, the system is augmented with a series of sequenced flashing lights. One is installed at each centerline bar starting 1000 feet from the threshold out to the end of the system. These flashing lights will flash in sequence toward the threshold and appear as a ball of light traveling toward the runway threshold.

The MALSR consists of steady burning and sequenced flashing lamps. A series of light bars with steady burning lights are located on the extended runway centerline at 200 foot intervals beginning at 200 feet from the threshold and extending to 1400 feet. A series of sequence flashing lamps are located at 200 foot intervals beginning at 1600 feet out to 2400 feet. There are three intensity levels for all flashing and steady burning lights. Lighting control is from the TCCC except when the airport is unmanned, and then via VHF radio from an aircraft. Like the ALSF-2 all lights are aimed into the approach to the runway.

For nonprecision instrument runways these medium intensity approach lights extend out to 1400 feet, for qualifying helipads with precision approaches, 1000 feet.

Omnidirectional Approach Lighting System (ODALS)

The Omnidirectional Approach Lighting System (ODALS) consists of a series of flashing lights that provide the pilot with visual guidance on nonprecision approach runways. ODALS provides the pilot with circling, offset, high angle, and straight-in visual guidance as dictated by individual airport size, type, service, and terrain characteristics.

Lead-In Lighting System (LDIN)

The Lead-in Lighting system is a configuration of sequenced flashing lights that provide the pilot with positive visual guidance usually along a curved

approach path where special problems exist due to hazardous terrain, obstructions, or noise abatement restrictions.

2.2.3.2 Landing Area Alignment, Height Perception, Roll Guidance and Horizontal Reference

The NAS provides visual aids that provide the user with information on landing area alignment, height perception, roll guidance, and horizontal references. Visual approach guidance is accomplished by using lighting systems which clearly indicate the approach end and centerline of the runway on which the pilot intends to land. It may also convey information to the pilot regarding his approach angle and approximate distance from the end of the runway.

Visual Approach Slope Indicator (VASI)

The VASI is a system of light bars arranged to provide visual approach slope guidance information during the approach to a runway. The basic principle of the VASI is that of color differentiation between red and white. Each light bar will project a split beam of light, the upper segment being white and the lower segment red. When on the proper glide slope in a two-light bar system, the downwind bar will appear white and the upwind bar will appear red; if the approach is too low, both bars will be seen as red; if the approach is too high, both bars will be seen as white. These lights are visible during clear weather for a minimum of 3 miles during daylight hours and 20 miles during night hours. Additionally, the VASI identifies the appropriate glideslope and incursions outside of acceptable approach slope tolerance.

Precision Approach Path Indicator (PAPI)

The PAPI is a nonprecision approach lighting system consisting of light units similar to the VASI. When on the proper glide slope, there will appear to be two red lights and two white lights. When the aircraft is slightly below glidepath, three red and one white lights will be seen. When the aircraft is further below the glideslope all four lights will be seen as red. Conversely, deviation above the glideslope will cause the red lights to turn successively white.

Runway-End Identifier Lights (REIL)

Runway End Identifier Lights (REILs) are installed at many airports to provide rapid and positive identification of the approach end of a particular runway. The system consists of a pair of synchronized flashing lights located laterally on each side of the runway threshold. REILs may be either omnidirectional or unidirectional facing the approach area. They are effective for identifying runways surrounded by other lighting, a runway that lacks contrast with surrounding terrain, and identifying a runway during reduced visibility.

Runway Lights

Runway edge lights are used to define the lateral limits of a runway. Runway lights are uniformly spaced at intervals of approximately 200 feet, and the intensity may be controlled or preset. Runway lights may be operated by airports authority or activated by pilots. The following are other types of runway lights that aid pilots.

Touchdown Zone Lighting (TDZL)

TDZLs consist of two rows of transverse light bars disposed symmetrically about the runway centerline in the runway touchdown zone. The system starts 100 feet from the landing threshold and extends to 3,000 feet from the threshold or the midpoint of the runway, whichever is the lesser.

Runway Centerline Lighting (RCLS)

Runway centerline lights are flush mounted centerline lights spaced at 50-foot intervals beginning 75 feet from the landing threshold and extending to within 75 feet of opposite end of the runway.

Runway Remaining Lighting

Centerline lighting systems are used in the final 3,000 feet as viewed from the takeoff or approach position. Alternate red and white lights are seen from the 3,000 foot points to the 1,000 foot points, and all red lights are seen for the last 1,000 feet of the runway. From the opposite direction, these lights are seen as white lights.

Taxiway Turnoff Lights

Taxiway Turnoff Lights are flush lights spaced at 50 foot intervals defining the curved path of aircraft travel from the runway centerline to a point on the taxiway. These lights are steady burning and emit a green light.

Heliport Lighting

The NAS also provides heliport lighting at selected heliports. The touchdown and lift-off surface (TLOF) located in a final approach and takeoff area (FATO) is defined with perimeter lights, illuminated with elevated flood lights, or a combination thereof. An odd number, but not less than 5, yellow omni-directional lights define the boundary of a square or rectangle TLOF. A minimum of 8 uniformly spaced lights define the boundary of a circular TLOF. The maximum spacing between lights in either case is 30 feet.

Elevated floodlights are used to provide illumination over heliport operational areas. They are be situated so as to prevent direct or reflected light from blinding the pilots. Floodlights may be mounted on buildings or poles which do not interfere with helicopter operations.

Taxi route lighting are omni-directional blue lights used to mark the limits of a taxi route. Above-ground lights are spaced at a maximum interval of 100 feet for straight sections and 50 foot for curved sections. A minimum of three lights are used to define a curve. Taxiway edge lights are omni-directional blue lights used to mark the edges of a taxiway. Above-ground lights are placed no more than 10 feet out from the pavement edge.

Landing direction lights are used to identify the alignment of the approach route. Landing direction lights consist of a line of five lights with omni-directional yellow lenses spaced at 15 foot intervals. Landing direction lights extend out from the line of perimeter lights in the direction of the approach.

The Heliport Instrument Lighting System (HILS) uses edge and wing light bars in addition to perimeter lights. Edge light bars consist of three unidirectional lights used to extend the right and left line of perimeter lights forward and rearward on each side of the takeoff and landing area.

These lights are spaced at 50 foot intervals. Wing light bars are three unidirectional lights used to extend the front and rear line of perimeter lights outward on each side of the takeoff and landing area. These lights are spaced at 15 foot intervals. Touchdown area lights consist of a line of seven bi-directional flush lights installed in the takeoff and landing pad. The lights are aligned in the direction of approach to provide close-in directional guidance and a measure of surface definition.

A Heliport Approach Light System (HALS) has ten light bars installed at 100 foot intervals out to a distance of 1000 feet. The first two light bars have one light each. The second pair of light bars have two lights in each bar. The third pair of light bars have three light each. The fourth pair of light bars have four lights each, and the fifth pair of light bars have five lights each.

2.2.3.3 Identification and Location of Airports

Rotating beacons at many airports provide for airport identification from a distance of 20 nautical miles at night and 3 nautical miles during daylight hours. At civil airports alternating white and green flashes indicate the location of a lighted land airport. At military airports the beacons flash alternately white and green but are differentiated from civil beacons by two quick (split) white flashes. White and yellow flashes from a rotating beacon indicates a lighted water airport; while white, green, and yellow indicates a lighted heliport. Flashing rate also helps to identify the type of airport. A flashing rate of 12 to 30 per minute indicates a land or water airport, while a flashing rate of 30 to 53 indicates a heliport.

The NAS provides lighting systems to locate and discriminate airports from surrounding features, such as city lights, terrain, and structures. Flashing red beacons and steady burning aviation red lights during nighttime operation and aviation orange and white paint during daylight operation help to differentiate an airport from surrounding cities and towns.

2.2.3.4 Marking of Obstructions Near Landing Areas

Obstructions within the terminal airspace are identified by lighting systems that are visible from 20 nautical miles in clear weather during hours of darkness. The NAS provides lighting and markings on those permanent obstructions on the airport surface that could pose a threat to departing, arriving, or taxiing aircraft.

These lighting systems can be a single light or a group of lights, usually red or white, frequently mounted on a surface structure or natural terrain to warn pilots of the presence of an obstruction. Examples of these are high intensity flashing white lights used to identify supporting structures of overhead transmission lines located across rivers, chasms, gorges, etc. These high intensity lights also identify tall structures, such as smokestacks and towers, as obstructions to air navigation. The lights provide a 360 degree coverage about the structure at 40 flashes per minute.

The NAS provides a means of visually marking/identifying taxiways, landing areas, landing area limiting characteristics, and other landing indicators. For example, taxiway/runway intersections and instrument landing critical areas are used to augment holding position markings denoting entrance to a runway or ILS/MLS critical areas. Runway/runway intersection signs are used to identify intersecting runways runway threshold designations of the intersecting runways. Taxiway identification signs are used to identify

taxiways by letters of the alphabet which are located at an intersection of taxiways or at an exit from a runway.

The NAS provides selected airports with lighting systems that provide obstruction clearance. The visual glide path of the VASI provides safe obstruction clearance within plus or minus 10 degrees of the extended runway centerline and up to 4 NM from the runway threshold. For heliports, obstruction clearance provided by the VASI is provided within plus or minus 10 degrees of the range of approved approaches to a minimum of 0.66 NM from the touchdown area.

2.2.3.5 Specialist Operation of Lighting Systems

Airport lighting system and approach lighting systems, including intensity settings, are controlled by specialists from the control tower. For airports without operating control towers, the airport lighting systems are controlled from another designated facility such as the AFSS or by the airport owner/operator.

2.2.3.6 User Operation of Lighting Systems

At selected airports where lighting is required, the pilot can remotely control airport lighting systems, i.e., approach, runway and taxiway lights. Of those visual approach guidance systems mentioned above, the MALSR system is controllable by the pilot via air-ground radio. Generally, three clicks of the microphone (within a 5 second period of time) will turn the MALSR to low intensity, 5 clicks to medium intensity, and 7 clicks to high intensity. A lighting system that is remotely turned on will automatically shut down after 15 minutes of operation.

2.2.3.7 Visual Aid Failure Alerts

The NAS alerts users and specialists to any known failures of visual aids that affect operations at the landing area.

2.3 Functions

The following paragraphs describe in more detail the functions provided by the specialist positions introduced in Section 2.1. The operational flow diagrams associated with each paragraph illustrate the information flow between the specialist within their respective facility and the user, and between the specialist and data processing equipment. The functions performed by the NAS are explicitly covered by requirements specified in the NASSRS. The pertinent NASSRS paragraphs that specify the function being performed by the NAS are referenced in each of the paragraphs that follow.

2.3.1 AFSS Specialist (Position 5: DF Specialist)

The DF specialist uses DF equipment to locate disoriented pilots. Figure 2-3 is an operational flow diagram describing the functions of the DF equipment. Functions performed by the equipment and specialist are lettered within each block and are described in the corresponding paragraphs below.

a. Direction Finder (DF). The DF equipment determines the aircraft's location from the radio signals transmitted from the aircraft.

   NASSRS Requirement 3.4.1.A

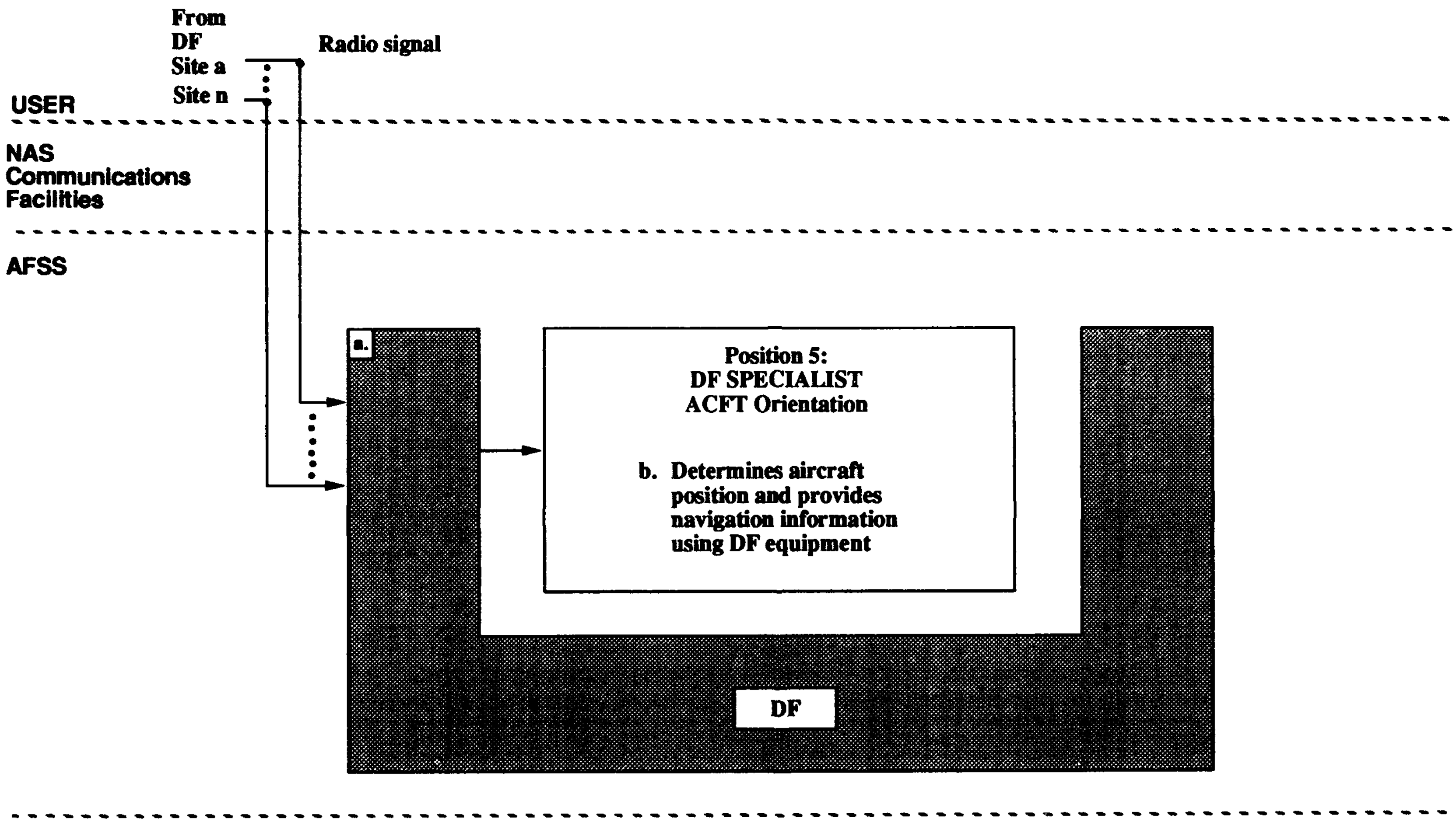

FIGURE 2-3
OPERATIONAL FLOW DIAGRAM, POSITION 5: DF SPECIALIST PROVIDING DF ASSISTANCE

b. Determines Aircraft Position. The specialist determines the aircrafts' position using the DF and provides navigation information to the pilot.

NASSRS Requirement 3.4.1.C

2.3.2 ACF Specialists (Positions 7 and 22: Radar En Route and Non Radar En Route Controllers)

The ACF monitors the aviation LORAN-C monitor for out of tolerance occurrences. Figure 2-4 is an operational flow diagram describing the interfaces provided to the specialists at the ACF. Functions performed by the equipment and these specialists are lettered within each block and are described in the corresponding paragraphs below.

a. ACCC Processing. The ACCC receives the operational status of LORAN-C from the LORAN-C aviation monitor. The ACCC in turn, alerts the ACF specialists of out of tolerance occurrences.

NASSRS Requirement 3.4.1.A., C

b. LORAN-C Aviation Monitor (AVLORMON) and GPS Monitor. The AVLORMON will monitor LORAN-C navigation signals to determine published correction values for nonprecision approach use in the NAS. The AVLORAN transmits LORAN-C status information to the ACCC. The NAS GPS (TBD) monitor will monitor the GPS signal and forward its status to the appropriate facility (TBD).

NASSRS Requirement 3.4.1.A, C; 3.4.2.A

c. Status of LORAN-C. ACF en route controllers are advised of out of tolerance occurrences of the LORAN-C and GPS. These controllers then advise aircraft of this situation.

NASSRS Requirement 3.4.1.A., C

2.3.3 ATCT Specialists (Positions 9 & 10: Local & Ground Controller)

Controllers in the ATCT are responsible for turning the appropriate approach, runway, and taxiway lighting systems on or off and adjusting the intensity to optimize their performance under the current visibility conditions at the airport. Tower controllers are also able to switch the airport instrument landing systems on or off, as appropriate to the runways in use.

Figure 2-5 is an operational flow diagram describing navigation interfaces provided to the specialists at the ATCT. Functions performed by the equipment and these specialists are lettered within each block and are described in the corresponding paragraphs below.

These controllers, through the lighting control capability in the TCCC, can turn approach lighting systems on or off and adjust the light intensities as appropriate for the runway configuration, time of day, weather conditions, and/or airport conditions. That capability exists for all approach lighting systems: ALSF-2, MALSR, LDIN, ODALS, REIL, VASI, and PAPI. Of these systems, only the ALSF-2 provides operational status input (feedback) to the TCCC. The other systems only reflect the status and intensity selected by the controller.

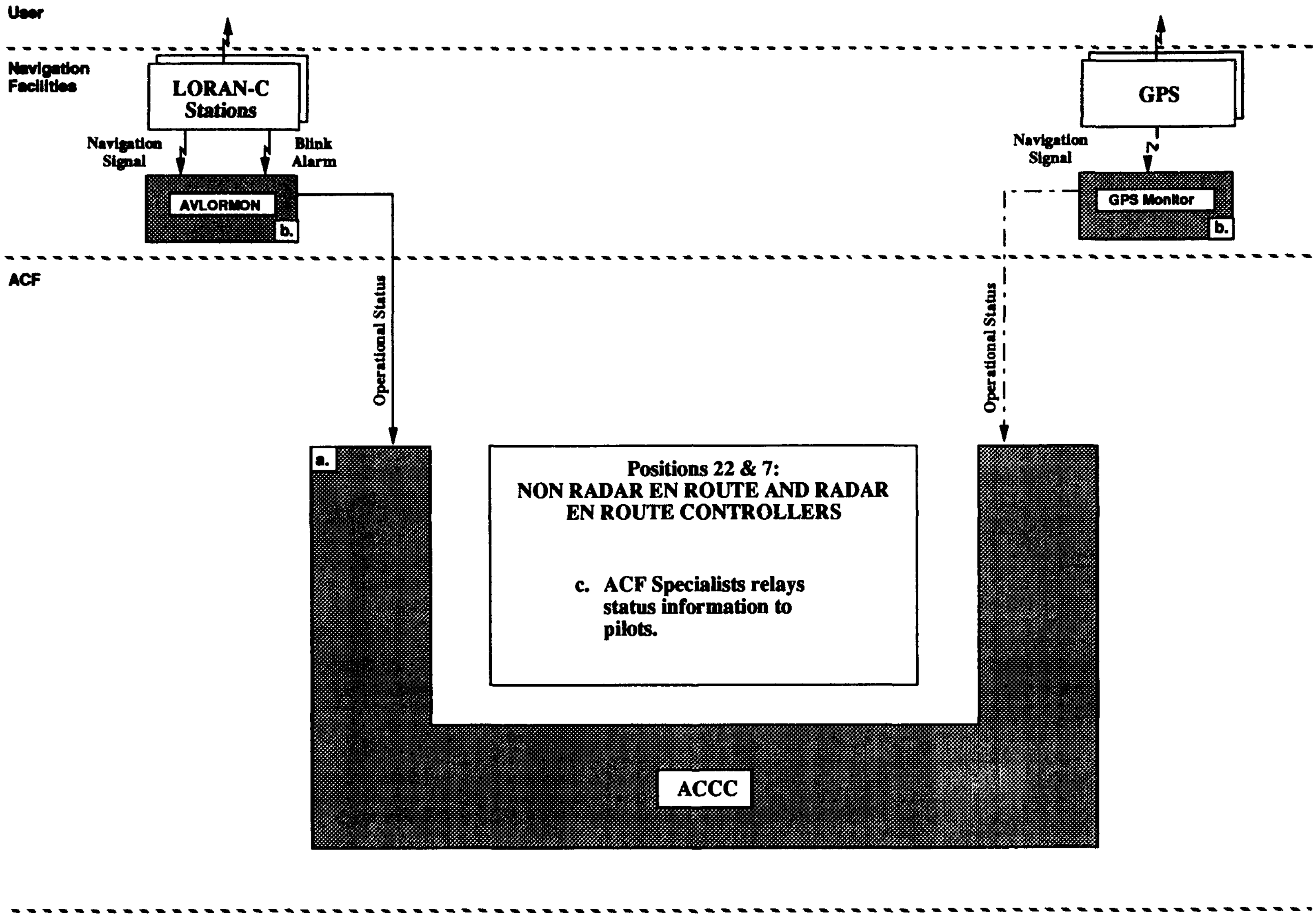

FIGURE 2-4
ACF DIAGRAM FOR NAVIGATION

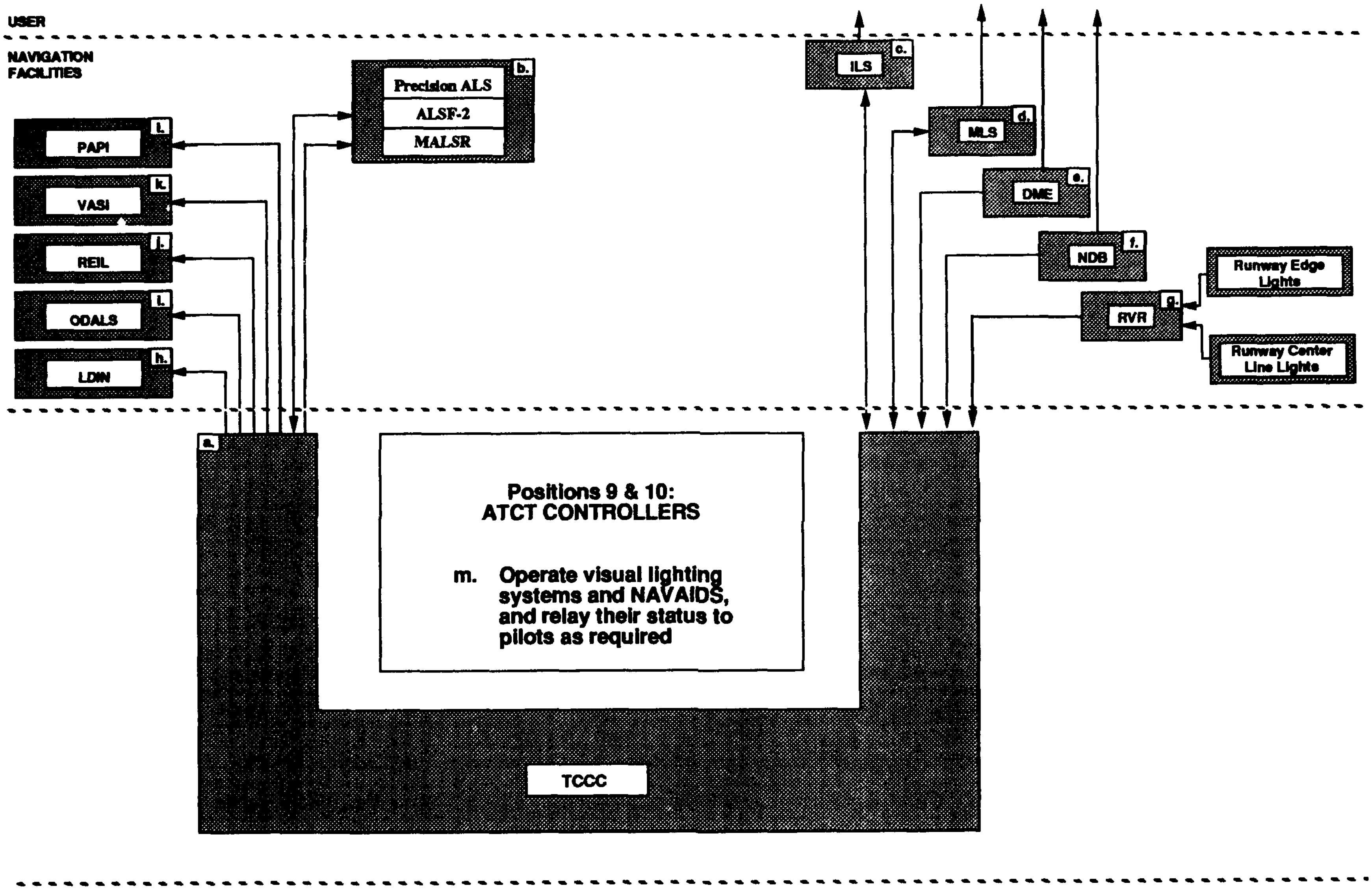

FIGURE 2-5
ATCT DIAGRAM FOR NAVIGATION

a. TCCC Processing. The TCCC provides the tower controllers with the operational control of the Approach Lighting Systems (ALSF 2/MALSR), Lead-In Lighting Systems (LDIN), Omnidirectional Approach Lighting Systems (ODALS), Runway-End Identifier Lights (REILS), Visual Approach Slope Indicators (VASI), Precision Approach Path Indicators (PAPI), and the Runway Visual Range (RVR). This information includes intensity levels, on/off status, or any occurrence of lamp failures. Operational status and control of the MLS and ILS is provided through the TCCC. DME and NDB provide operational status to the TCCC only if they are collocated with an ILS. This status information is also displayed to this ATCT controller. RVR data is provided for each RVR equipped runway to the TCCC. The RVR also provides operational status to the TCCC for the runway edge and runway centerline lights.

   NASSRS Requirement 3.4.2.A., C

b. Precision Approach Lights Systems (ALSF-2/MALSR) Output to approach lights consist of the control instructions from the lighting control capability in the TCCC which permits the controller to turn the equipment on or off and adjust the light intensities as appropriate for the runway configuration, time of day, weather conditions, airport conditions, etc. This interface provides the air traffic controller in the ATCT with operational control of the ALSF-2 or MALSR intensity levels and on/off functions.

   NASSRS Requirement 3.4.3.B, E

c. Instrument Landing System (ILS) The TCCC receives operational status from the ILS and displays it to the controller. Operational control of the ILS is provided to the controller.

   NASSRS Requirement 3.4.2.A & C

d. Microwave Landing System (MLS) The TCCC receives operational status from the MLS and displays it to the controller. Operational control of the MLS is provided to the controller.

   NASSRS Requirement 3.4.2.A & C

e Distance Measuring Equipment (DME) This interface exists only if the DME is collocated with an ILS. The TCCC receives operational status from the DME and displays it to the controller.

   NASSRS Requirement 3.4.2.A

f. Non-Directional Beacon (NDB) This interface exists only if the NDB is collocated with an ILS. The TCCC receives operational status from the NDB and displays it to the tower controller.

   NASSRS Requirement 3.4.2.A

g. Runway Visual Range (RVR) Input from the RVR is measured visual range down the runway, and runway light intensities. The RVR interfaces with the associated runway edge lights and runway centerline lights to determine their intensity settings. Operational status of the RVR is transmitted to the TCCC.

   NASSRS Requirement 3.4.3.B

h Lead-In Lighting System (LDIN) This interface provides the tower controller with operational control of the LDIN; i.e., on/off control and intensity control.

NASSRS Requirement 3.4.3.A, H

i. Omnidirectional Approach Lighting System (ODALS) This interface provides tower controllers with operational control of the ODALS which, in this case, is limited to on/off control.

NASSRS Requirements 3.4.3.A, H

j. Runway-End Identifier Lights (REIL) The REIL/TCCC interface provides the ATCT controller with operational control; i.e., on/off and intensity control.

NASSRS Requirement 3.4.3.A, H

k. Visual Approach Slope Indicator (VASI) This interface provides the controller in the tower with on/off and intensity operational control for the VASI.

NASSRS Requirement 3.4.3.A, H

l. Precision Approach Path Indicator (PAPI) The PAPI interfaces with the TCCC to provide on/off operational control from the tower.

NASSRS Requirement 3.4.3.A, H

m. Operational Control and Status of NAVAIDS ATCT controllers operate visual lighting systems and relay the status of NAVAIDs, landing and visual aids to pilots as needed.

NASSRS Requirement 3.4.2.C

2.4 Correlation with Operational Requirements

Table 2-2 correlates the navigation operational requirements paragraphs of NAS-SR-1000 with the paragraphs that describe the functions being performed by the specialists/controllers. All paragraph numbers in NAS-SR-1000 associated with navigation have been listed; however those paragraphs that are either introductory in nature, do not state explicit operational requirements, or reference other portions of NAS-SR-1000 are indicated by a hyphen. The fact that a correlation has been made between a requirements paragraph and a paragraph describing a specialist/controller function should not be construed to mean that the requirement is being completely fulfilled by the function described.

2.5 Operational Sequence

Operational sequence diagrams have been developed to illustrate the interactions between users (pilots) and navigational systems. The diagrams are general in nature and are intended to provide an overall depiction of the navigation system. Operational sequences are based on the end-state NAS as described in baselined documents (e.g., Level I Design Document). The numbers in the upper right hand corner of each "box" and upper vertices of the decision diamonds are reference numbers and progress as time progresses during the operation. The numbers are intended to help the reader trace the use of navigational facilities by their respective users. Specific situations are

Table 2-3
Navigation Connectivity Operational Requirements Correlation

NAS FACILITIES / NAS-SR-1000 PARAGRAPH	INFORMATION													AFSS SPEC.		ACF SPEC.			ATCT SPECIALISTS												
	2.2.1.1	2.2.1.2	2.2.1.3	2.2.2.1	2.2.2.2	2.2.2.3	2.2.3.1	2.2.3.2	2.2.3.3	2.2.3.4	2.2.3.5	2.2.3.6	2.2.3.7	2.3.1.A	2.3.1.B	2.3.2.A	2.3.2.B	2.3.2.C	2.3.3.A	2.3.3.B	2.3.3.C	2.3.3.D	2.3.3.E	2.3.3.F	2.3.3.G	2.3.3.H	2.3.3.I	2.3.3.J	2.3.3.K	2.3.3.L	2.3.3.M
3.4.1 EN ROUTE NAVIGATION	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3.4.1.A Provision & Support of Navigation Networks	x													x		x	x	x													
3.4.1.B Compatibility with Approved User Equipment		x																													
3.4.1.C Info on Status & Location of Specific Nav Aids			x												x	x	x	x													
3.4.2 TERMINAL NAVIGATION	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3.4.2.A Navigational Capabilities at Specified Airports				x													x		x		x	x	x	x							
3.4.2.B Navigational Capabilities Available Continuously					x																										
3.4.2.C Monitoring & Alerts on Navigational Status & Performance						x													x		x	x									x
3.4.3 VISUAL NAVIGATION AIDS	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3.4.3.A Curved, Offset & Straight-In Guidance for Visual & Non-Precision Approaches							x																			x	x	x	x	x	
3.4.3.B Landing Area Alignment, Height Perception, Roll Guidance & Horizontal Reference								x												x					x						
3.4.3.C Identification & Location of Airports									x																						
3.4.3.D Marking of Obstructions near Landing Areas										x																					
3.4.3.E Specialist Operation of Lighting Systems											x									x						x	x	x	x	x	
3.4.3.F User Operation of Lighting Systems												x																			
3.2.3.G Visual Aid Failure Alert													x																		

developed as scenarios in Section 2.6.

2.5.1 En Route/Terminal/Visual Navigation Operational Sequence

In Figure 2-6 a pilot tunes in the en route VOR (1), receives its signal (2), that transmits continuously (3). The pilot navigates using the VOR (4). The pilot, entering the terminal area transitions to the terminal VOR (5), receives its signal (6) which is located on the airfield and transmits on a continuous basis (7) and navigates to the airport (8). At a point approximately ten miles from the airport the pilot transitions to the instrument landing system (9). The aircraft's onboard avionics receive the ILS signals (10). The ILS provides runway alignment, elevation and range information (11) and is used by the pilot to position the aircraft for landing (12). At a half-mile from the end of the runway the pilot visually acquires the airport (13) then uses the VASI to guide the aircraft (14). The VASI provides visual guidance for elevation (15) that the pilot uses to land (16). Once the pilot lands centerline lights (17) embedded in the runway are used to keep the aircraft aligned (18) down the middle of the runway. At the end of the runway the pilot turns the aircraft onto the taxiway (19) and uses the taxiway lights (20) for guidance to the ramp (21).

2.5.2 Terminal Navigation (Nonprecision) Operational Sequence

Figure 2-7 describes the use of a VOR for use in a terminal area for both navigation to an airport and for the approach to the runway. In this sequence a pilot tunes in the frequency of a VOR to navigate to an airport per the ATC clearance (1). The pilot receives its signal (2) which sends out its signal on a continuous basis (3). Once within the terminal area the pilot decides to use the same VOR to execute a VOR approach to the runway (4). Since the VOR can only provide azimuth (course) information and not elevation information (altitude) the pilot must calculate his correct decent rate after beginning the approach. Once the pilot crosses the VOR station (5) and begins his decent, he continues to use the VOR signal for course information to the runway. Once at the missed approach point (6) the pilot, seeing the runway (7), terminates the instrument portion of the approach and continues to the runway visually to land (8).

2.5.3 Visual Aid to Navigational Operational Sequence

Figure 2-8 describes the use of visual navigation aids to locate an airport at night without an operating control tower. In this sequence a pilot locates the airport's rotating beacon (1). Flying towards the rotating beacon the pilot tries to locate other airfield lighting systems that will help further differentiate the airport (2). Noticing that the runway lights are not on (3) the pilot keys the radio transmitter (set to the appropriate frequency) 7 times rapidly (4) which activates the visual aids to the runway and runways lights (5). Since this procedure activates the lights to their highest intensity, the pilot keys the frequency 5 times (6) which in turn lowers the intensity of the runway lights (7). The pilot lands the aircraft (8) and taxies off the runway to the ramp (9). Approximately 15 minutes after activation the visual aids and runway lights automatically shut off (10).

2.5.4 Navigational Monitor Operational Sequence

Figure 2-9 In this particular sequence a pilot on a VFR flight plan wishing to navigate using a particular navigation aid tunes in the NAVAID (1). The pilot receives the NAVAID signal (2). The NAVAID transmits its signal normally (3) and is being monitored at the delegated facility (4). When the NAVAID malfunctions (5) at the same time the monitoring facility receives the

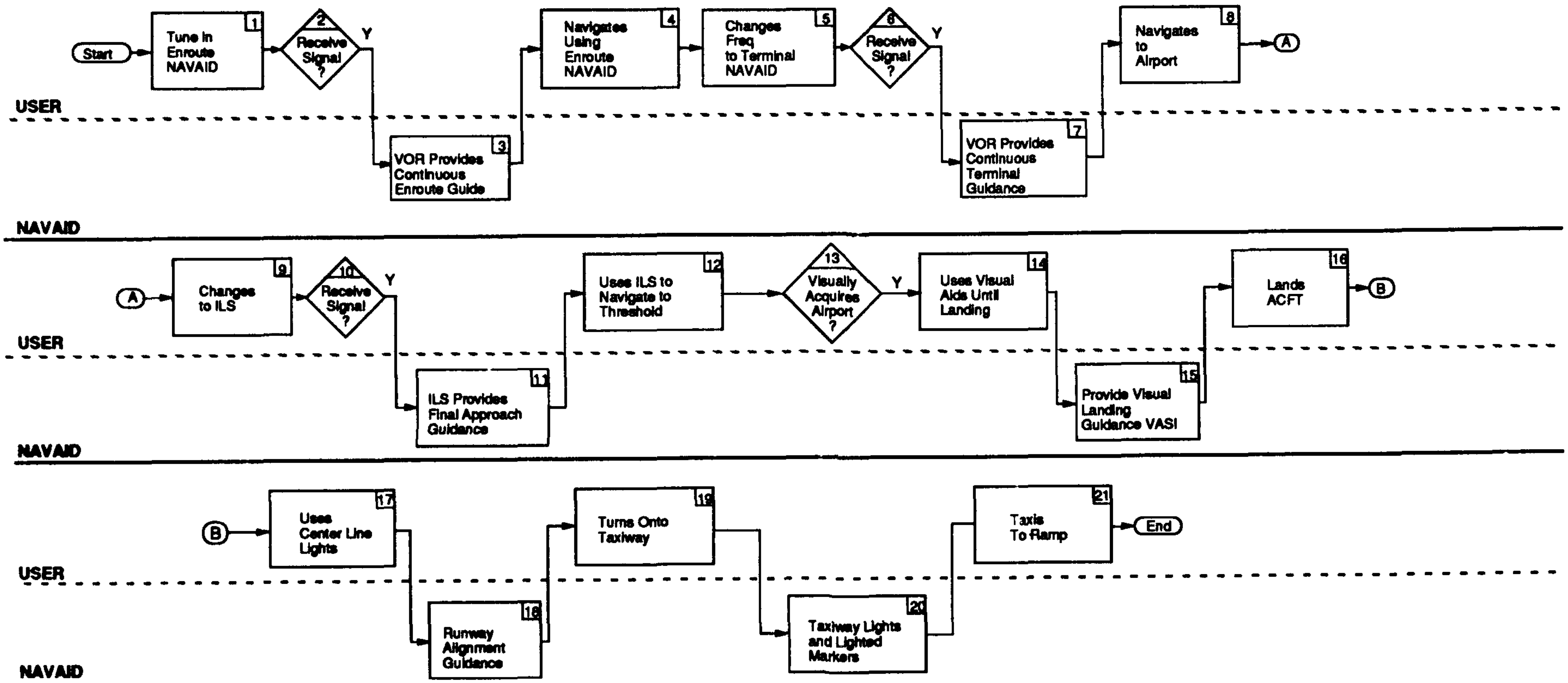

FIGURE 2-6
EN ROUTE/TERMINAL/PRECISION
APPROACH/VISUAL NAVIGATION SEQUENCE

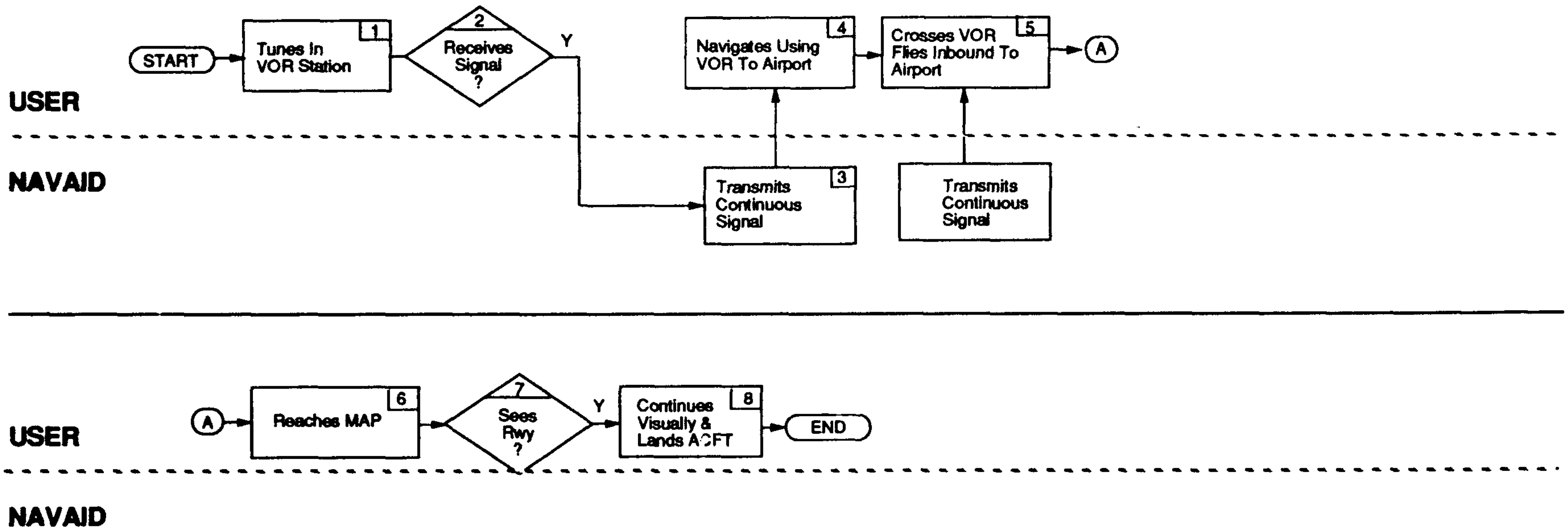

FIGURE 2-7
TERMINAL NAVIGATION (NONPRECISION)
OPERATIONAL SEQUENCE

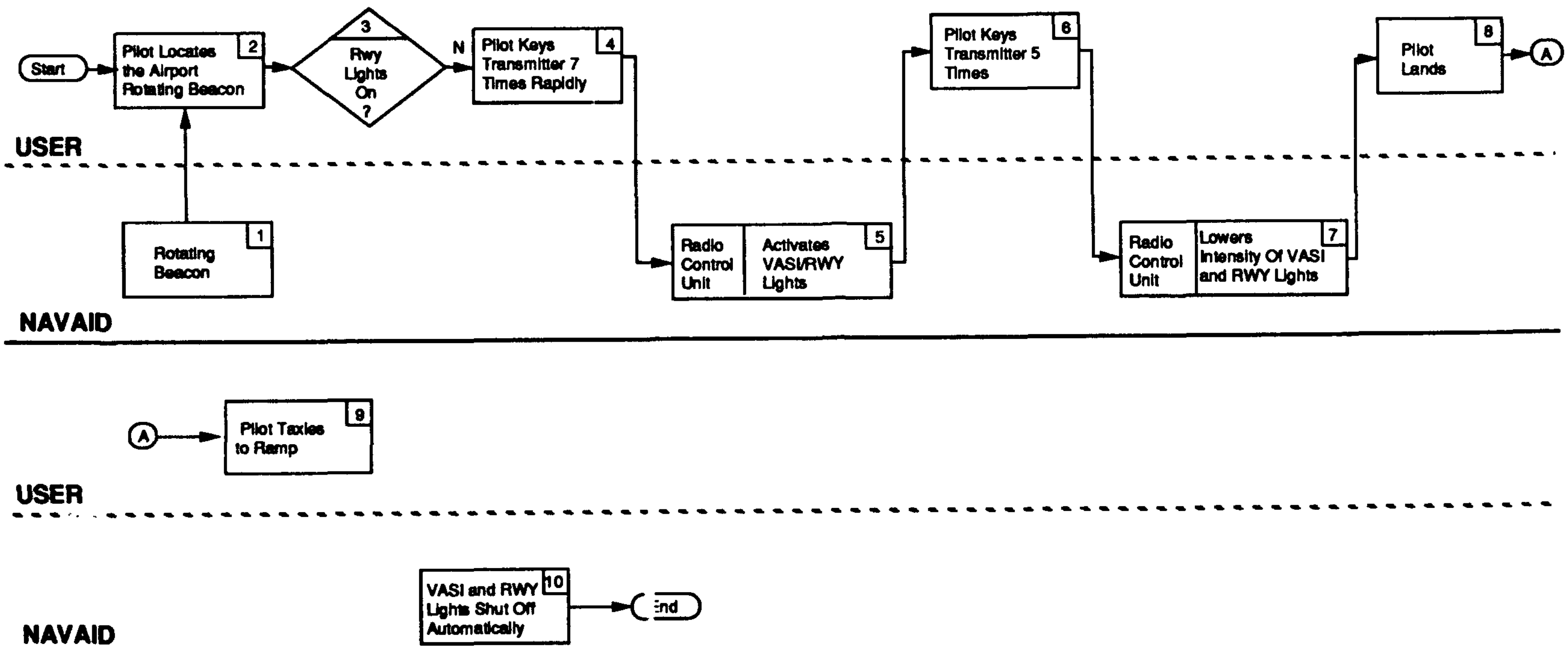

FIGURE 2-8
PILOT CONTROL OF AIRFIELD
LIGHTING SEQUENCE

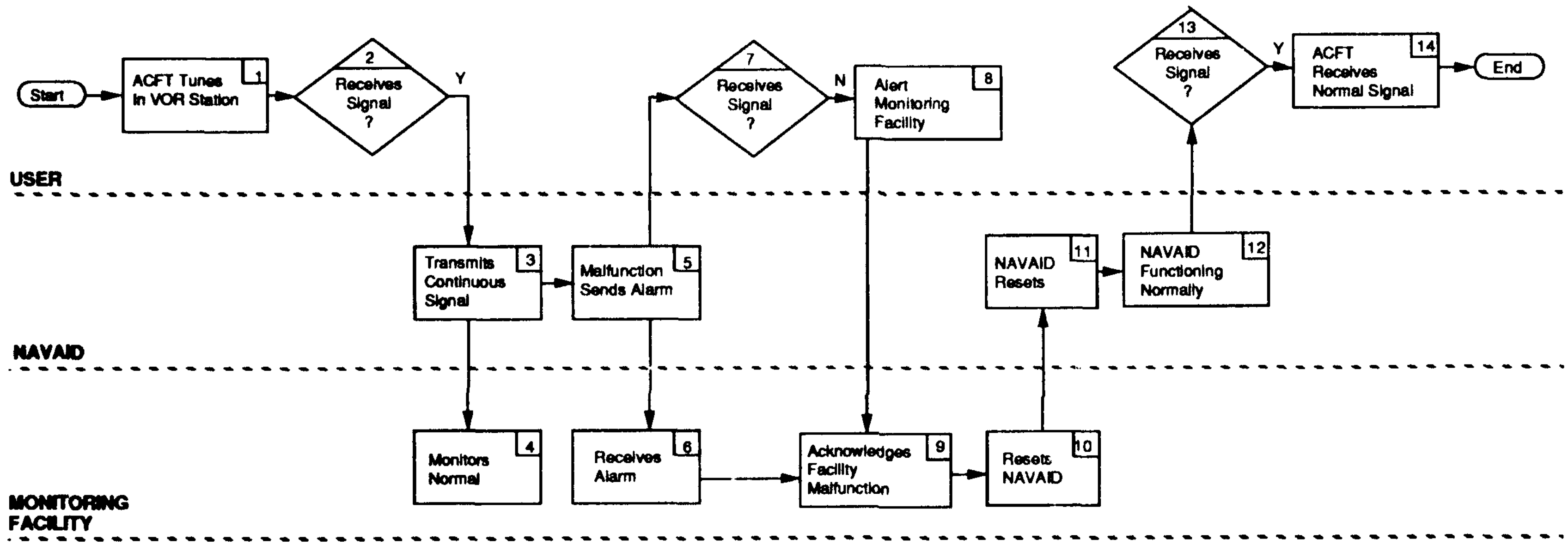

FIGURE 2-9
NAVAID MONITOR SEQUENCE

alarm (6) that the NAVAID has gone off the air. The pilot notices the loss of signal (7). The pilot continues the present heading VFR and contacts the facility monitoring the NAVAID (8) and advises that the NAVAID is no longer transmitting. The monitoring facility acknowledges (9) and changes transmitters and resets the NAVAID (10) via remote control. The NAVAID successfully resets (11) and begins to transmit its signal again (12). The pilot receives the NAVAID signal again (13) and continues on course (14).

2.5.5 Area Navigation

In this sequence (Figure 2-10) a pilot wishes to use a supplemental navigation system to navigate to the destination airport. The pilot is initially cleared via a Victor airway. Rather than navigating using the VOR receiver the pilot chooses to navigate using RNAV through the on-board Flight Management System (FMS). The pilot enters the departure location and destination airport into the FMS (1). The pilot then enters the three letter identifiers for the three VORTACs that will be used en route to the destination (2). The FMS calculates and displays the three waypoints that the aircraft will over fly en route (3). After takeoff and initial departure separation is accomplished the pilot is cleared on course (4). The FMS selects waypoint "A" (5) and directs the autopilot to turn the aircraft towards it. The pilot determines that the signal is acceptable for navigation (6). When the pilot selects waypoint "B" (7) the FMS alerts the pilot that it is not receiving the signal (8) due to the VORTAC being out of service (9). The pilot selects another NAVAID within range that can be used to navigate on the route. In this case an NDB is selected and its three letter identifier is loaded into the FMS (10). The FMS receives the signal from the NDB (11) which transmits its signal continuously (12). Upon reaching waypoint "B" the FMS switches to waypoint "C" (13) and receives the signal from VORTAC C continuously (14). Upon reaching the terminal area the pilot is issued further instructions to his destination (15).

2.6 Operational Scenario

Specific hypothetical situations illustrating navigation capability within the NAS are presented in the following paragraphs.

2.6.1 En Route Navigation Operational Sequence

Figure 2-11 illustrates a scenario describing operator/user interactions between the navigational avionic systems aboard an aircraft and the navigational aids that are used on the ground. In this scenario the clearance given to the crew of United flight 213 was from J.F. Kennedy International Airport, NY, to Miami International Airport FL, is to depart via the JFK Four Departure (SID) WAVEY NATLE J174 DIXON AR14 METTA AR1 HOBEE BLUFI FOUR ARRIVAL (STAR) MIA. After departure the pilot turned left and proceeded direct to the Canarsie VOR/DME navigational facility using the VOR receiver (1). Once crossing the Canarsie VOR the pilot is issued a heading by ATC towards the NATLE intersection and is instructed that, upon intercepting the 234 radial of the Hampton VORTAC (J174) (2), resume his own navigation via J174. Using the VOR receiver the pilot engages the Flight Mangagement System (FMS) which locks onto the Hampton VORTAC and, upon intercepting the 234 radial, the autopilot turns the aircraft onto J174 (3). At a point 140 NM from Hampton the pilot tunes in the Snow Hill VORTAC and the FMS continues to navigate the aircraft on J174 (4). Prior to reaching Snow Hill the pilot tunes in the Norfolk VORTAC, and after crossing Snow Hill, switches to the Norfolk VORTAC frequency for guidance on J174 (5). The aircraft will continue using Norfolk until a point 85 NM south of Norfolk (the CLAPY intersection J174) where the pilot tunes in the Dixon NDB/DME navigational aid (6) and continues inbound on J174.

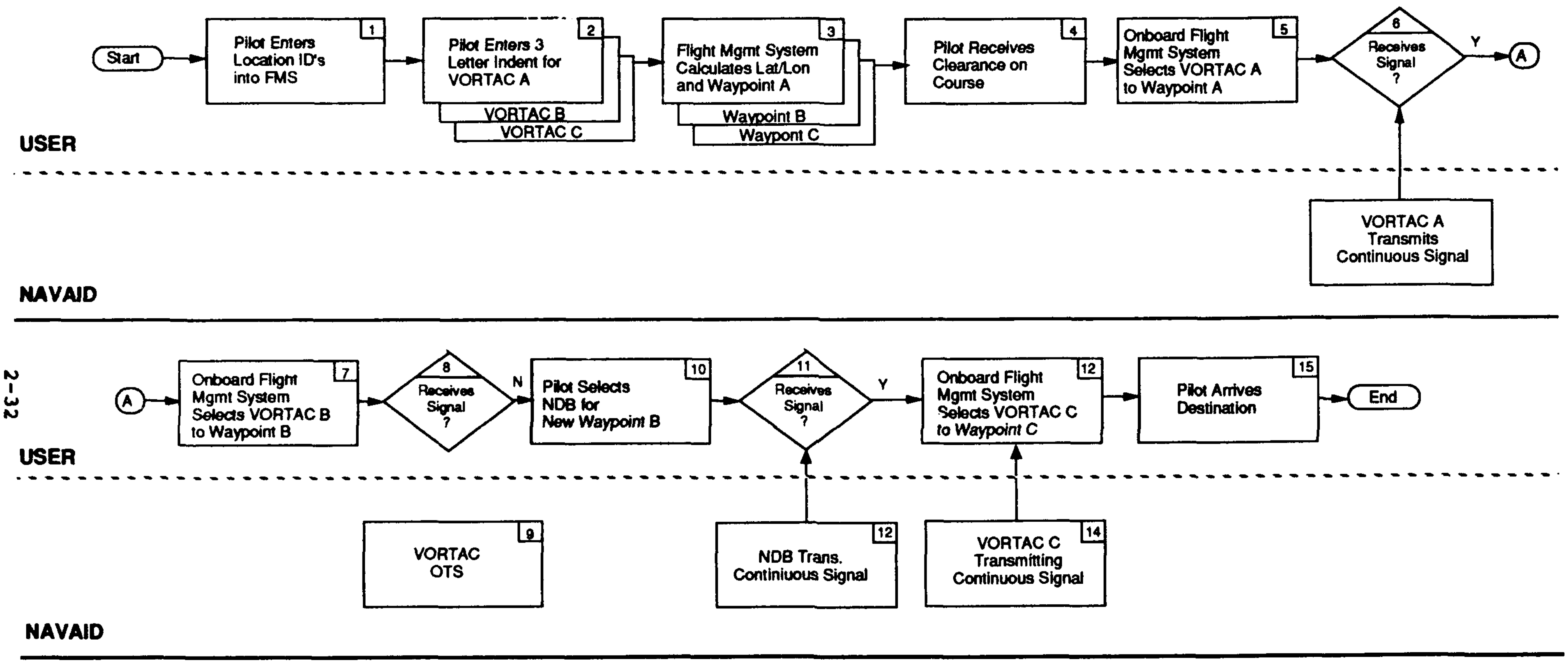

FIGURE 2-10
AREA NAVIGATION (SUPPLEMENTAL)

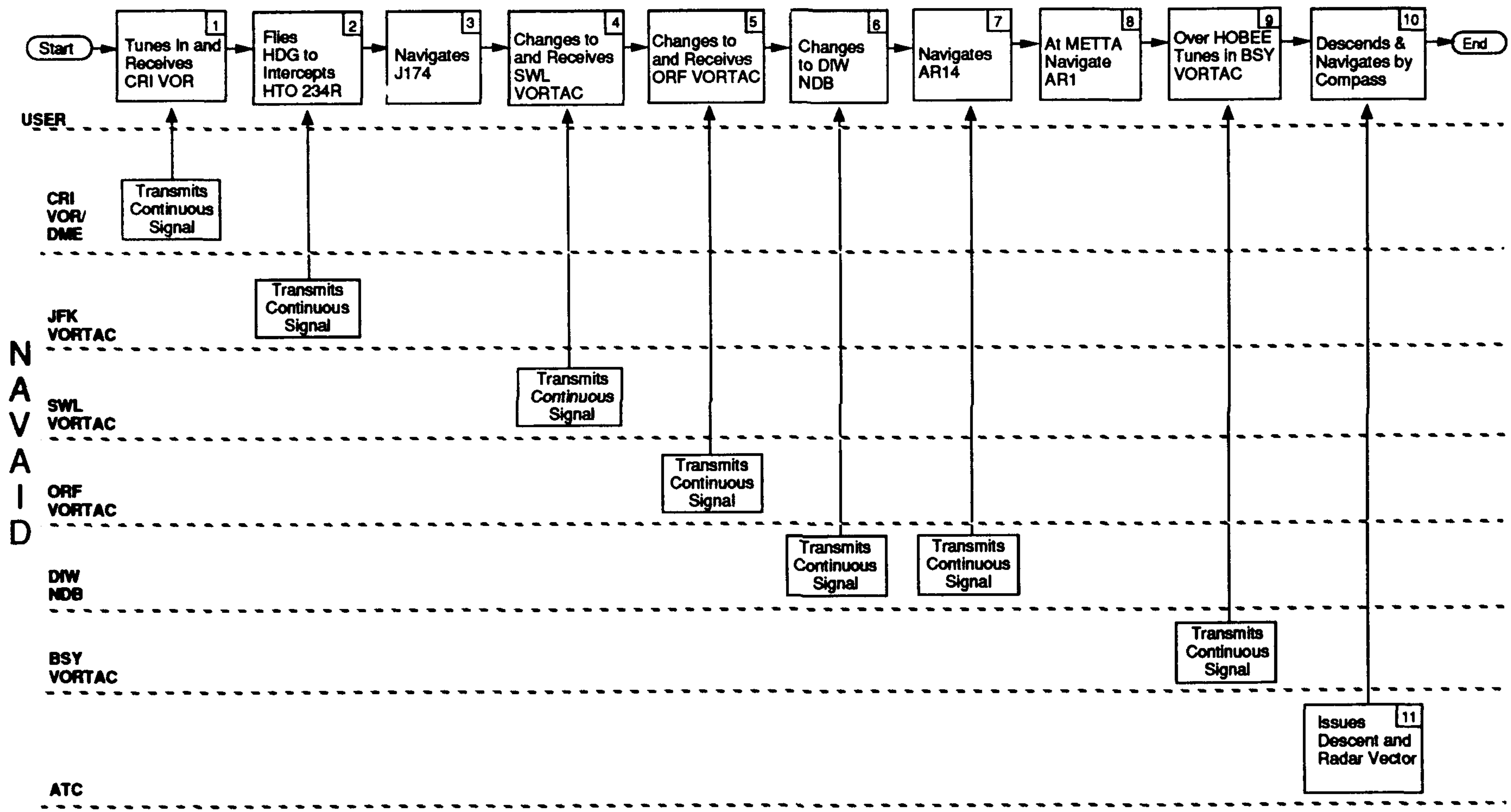

FIGURE 2-11
EN ROUTE NAVIGATION

After crossing the Dixon NDB the pilot sets the FMS to fly outbound from Dixon and navigate on AR14 (7). The aircraft continues to fly outbound on AR14 until the METTA intersection (102 NM south of Dixon) at which point the pilot sets the FMS to navigate using AR1 (8) until the HOBEE intersection. While still in the en route phase of navigation the pilot will use the BLUFI Four STAR as a reference. The FMS will continue navigating using the Dixon NDB until a point 219 NM from Dixon whereby the pilot switches to the Biscayne Bay VORTAC for navigating on AR1 (9). Prior to BLUFI intersection the pilot is issued descent instructions (10) and after crossing the HONOE intersection on AR1 is issued radar vectors (11) for landing at Miami International.

2.6.2 Terminal Navigation Operational Sequence

Figure 2-12 describes the actions taken by a pilot during a precision approach at a specified airport. In this scenario a pilot tunes in the frequencies of the particular ILS localizer and glideslope (1). Both components radiate their signal continuously and the pilot receives the localizer signal first (2). The pilot receives the signal for the localizer and turns the aircraft to intercept the localizer (aligning the aircraft with the final approach course) (3). Once the pilot has intercepted the localizer signal and aligned the aircraft (4), the pilot continues to make corrections to his course, as required, to stay on the localizer. At approximately 5.5 miles from the runway the pilot starts to intercept the glideslope signal (5) which also radiates continuously (6). The pilot continues to maintain his course using the localizer (7) and will maintain his current altitude (8) until he reaches the outer marker (9) which radiates continuously (10). The Outer Marker, in this case, coincides with the final approach fix and the point at which the pilot is to begin descent. Crossing the outer marker (approximately 5 miles) the pilot begins descent using the glideslope indications (11) received. The pilot continues his course and descent rate using the localizer (12) and glideslope (13) signals. The pilot continues descent until he reaches the decision height at the same time he crosses the middle marker (14) which continuously sends its signal (15). At this point the pilot must visually acquire the landing environment and land or execute a missed approach. If the pilot cannot see the runway or runway environment, (16) he must execute the missed approach procedures (17). If the pilot does see the runway or runway lights (18) he visually continues his approach and lands the aircraft (19).

2.6.3 Visual Aid Navigational Operational Sequence

In Figure 2-13 the pilot of Cessna 23486 inbound to Frederick Municipal Airport, Frederick, MD, enters the downwind leg to Runway 23. The pilot wishes to make an approach to the runway but is not qualified to execute either of the two instrument approaches to Runway 23. Instead, the pilot will navigate visually to the runway using the omnidirectional approach lighting system (ODALS). As the pilot turns base leg to Runway 23 he sees the ODALS flashing (1). He sees two flashing white lights, one on either side of the approach end of the runway (2) and then spots the five flashing lights (3) that lead toward the approach end (4). The pilot will turn the aircraft to line it up with the five sequenced flashing lights to visually aligning them in between the two flashing lights either side of the runway (5). Now that the pilot has aligned his course correctly he looks for the visual approach slope indicator (VASI) (6) to start his descent towards the runway. The pilot sees the VASI on the right side of the runway, giving him the indication the aircraft is too high (both boxes are white) (7). The pilot adjusts his descent rate (8) until the upper box is red and the lower box is white (9) indicating the aircraft is at the correct approach attitude. The pilot continues to align the aircraft to the ODALS for course guidance and VASI for

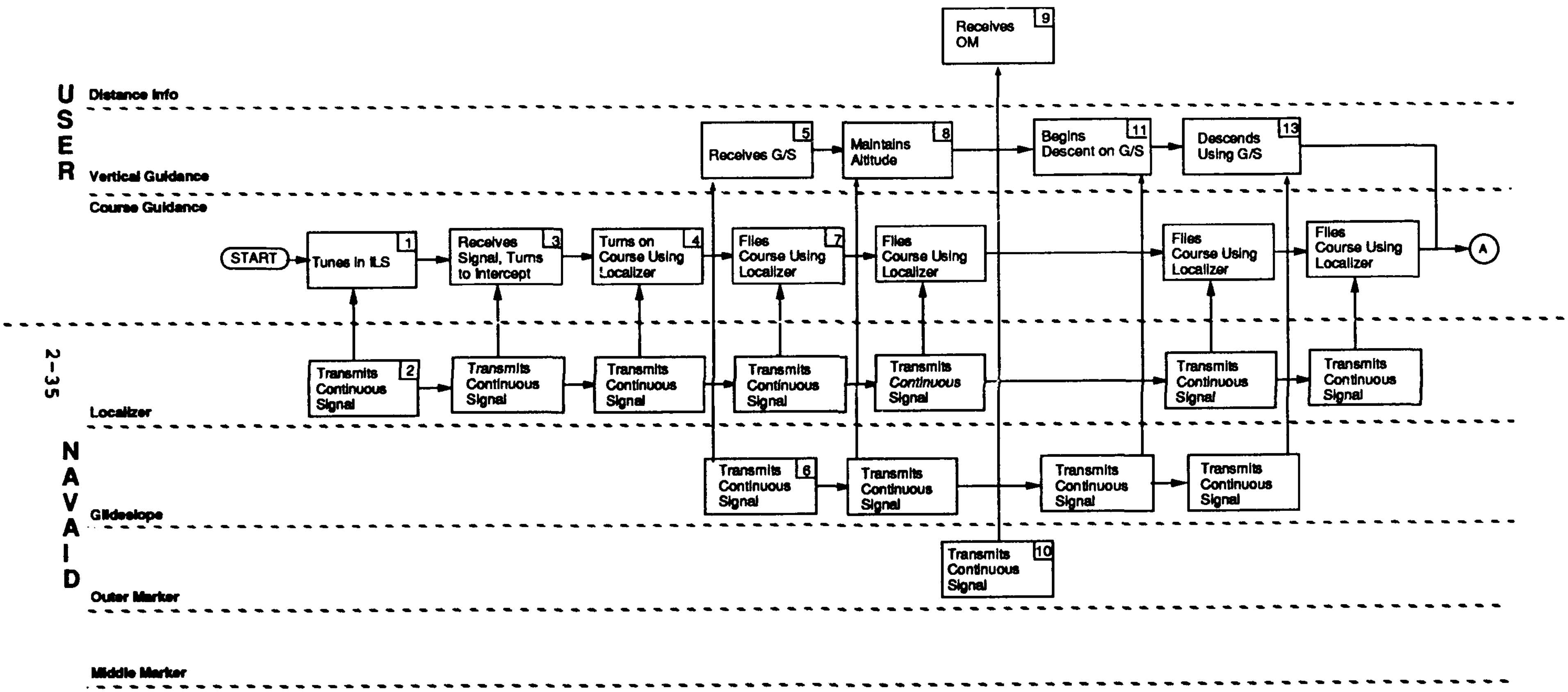

FIGURE 2-12a
PRECISION APPROACH SCENARIO

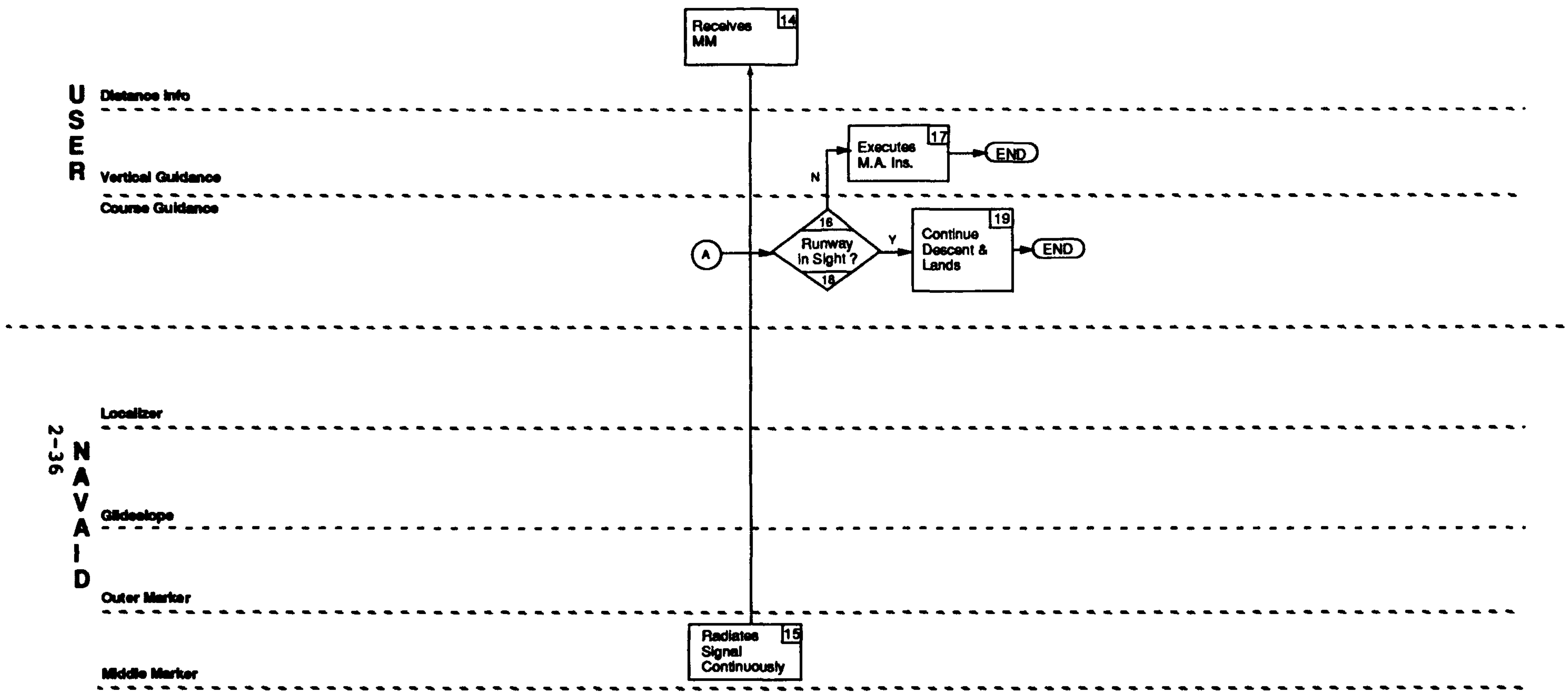

FIGURE 2-12b
PRECISION APPROACH SCENARIO

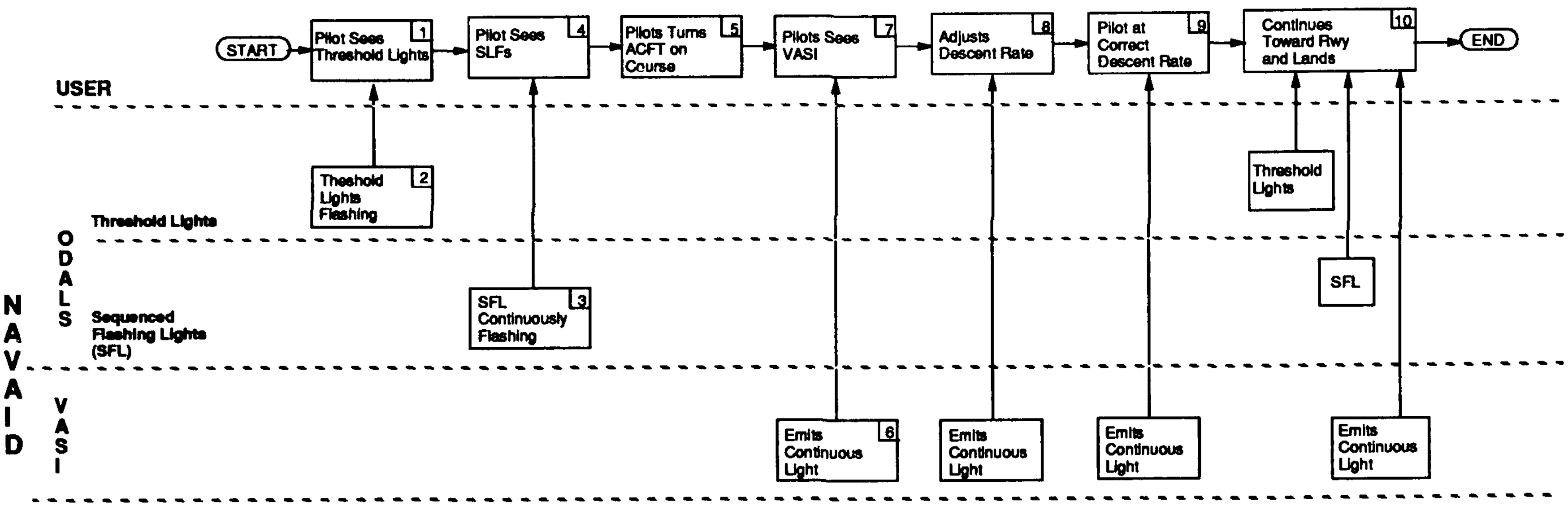

FIGURE 2-13
VISUAL NAVIGATION OPERATIONAL SCENARIO

elevation guidance (10) until the aircraft is over the landing threshold.

2.6.4 NAVAID Monitor Operational Scenario

In Figure 2-14 a pilot requests a LORAN-C nonprecision approach into the Washington County Regional Airport, Hagerstown, MD (1). The pilot is receiving the LORAN-C signal (2) and the AVLORMON monitoring is normal (3). The AVLORMON sends a normal signal to the Washington ACF's ACCC (4). The controller clears the pilot for the LORAN-C approach (5) into Hagerstown. The pilot acknowledges the clearance (6) and starts to align the aircraft for approach (7). However, prior to starting the approach a LORAN station fails (8) and the pilot no longer receives the signal (9). The AVLORMON receives an abnormal signal (10) and the abnormal indication is received at the ACCC (11). The ACCC alerts the controller working the Hagerstown sector (12). The controller advises the pilot (13) who tells the controller that the aircraft is VOR equipped (14). The controller then clears the pilot direct to the Hagerstown VOR (15). The pilot tunes the Hagerstown VOR frequency (16) and receives its signal (17). The controller clears the pilot for the VOR approach (18). The pilot executes the VOR approach into the Hagerstown Airport (19).

2.6.5 Area Navigation Operational Scenario

In Figure 2-15 the pilot of N123DC, a Gulfstream 4, has filed St Louis RNAV direct to Leesburg Municipal Airport, Leesburg Virginia. The pilot intends to utilize on-board avionics to fly the direct route using waypoints calculated from the VORTACs along the route of flight direct to the MILLY initial approach fix for an RNAV approach into Leesburg. However, due to traffic ATC has cleared N123DC from St Louis via the St Louis Three Departure (SID), Centralia VORTAC (ENL) direct Louisville (IIU) direct Beckley (BKW) J213 DOCCS intersection direct MILLY direct Leesburg (JYO). Since the coordinates for each VORTAC and intersection are published and the pilot has the data for these fixes already loaded into his navigational computer, he loads the three letter identifier for the VORTAC and the five letter identifier for the intersections and the route of flight is automatically loaded into the navigational system. After departure the pilot is given a radar vector (1) towards Centralia (2) and instructed upon receiving the VORTAC to proceed direct. Once the autopilot is engaged the aircraft will continue direct (3) Centralia. After Centralia the autopilot turns the aircraft to proceed direct Louisville (4). After passing Louisville, the autopilot turns the aircraft direct to Beckley (5). After passing the Beckley VORTAC the aircraft will navigate on J213 (6) to the DOCCS intersection. Prior to DOCCS ATC issues a descent to the pilot (7). The pilot descends (8) and after passing DOCCS the aircraft proceeds towards the MILLY intersection and, upon reaching it, the pilot will execute the RNAV Runway 17 approach (9) into Leesburg.

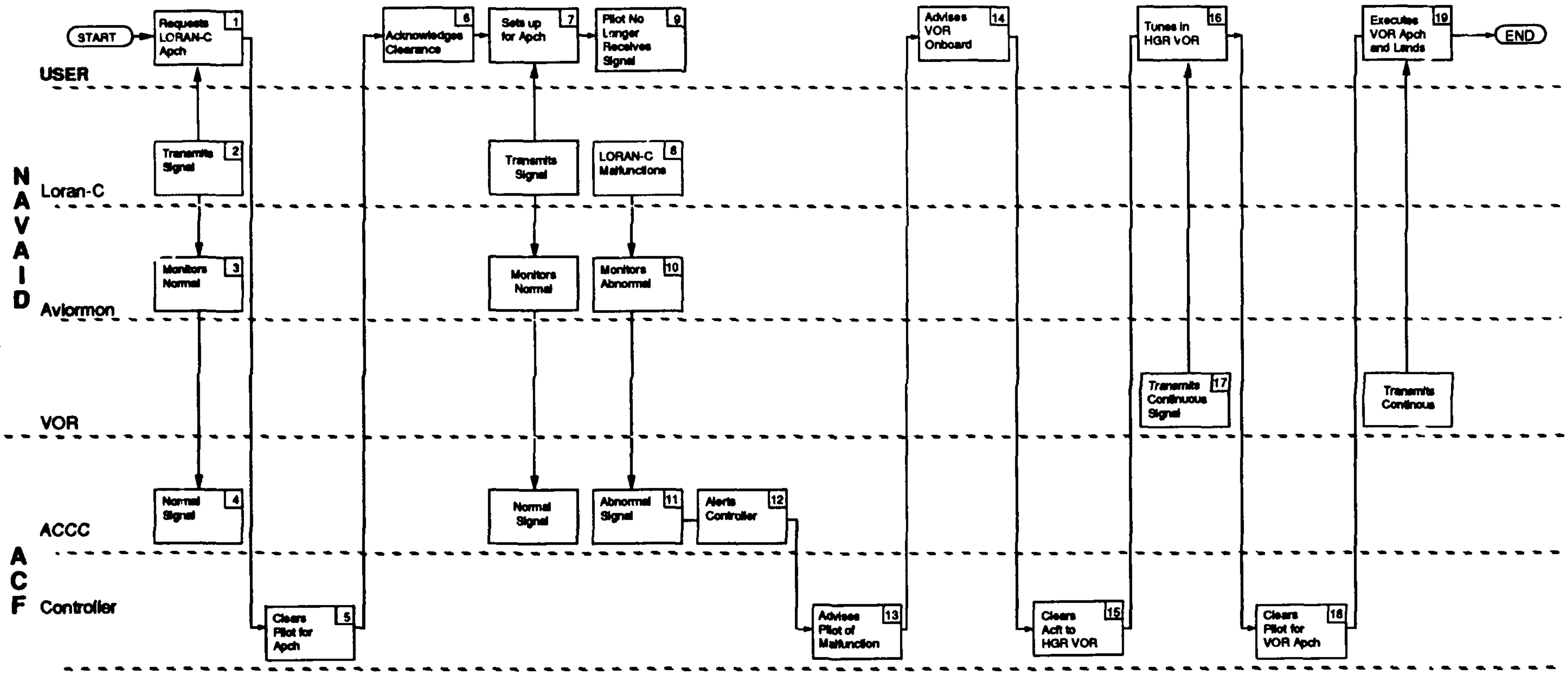

FIGURE 2-14
NAVAID MONITOR OPERATIONAL SCENARIO

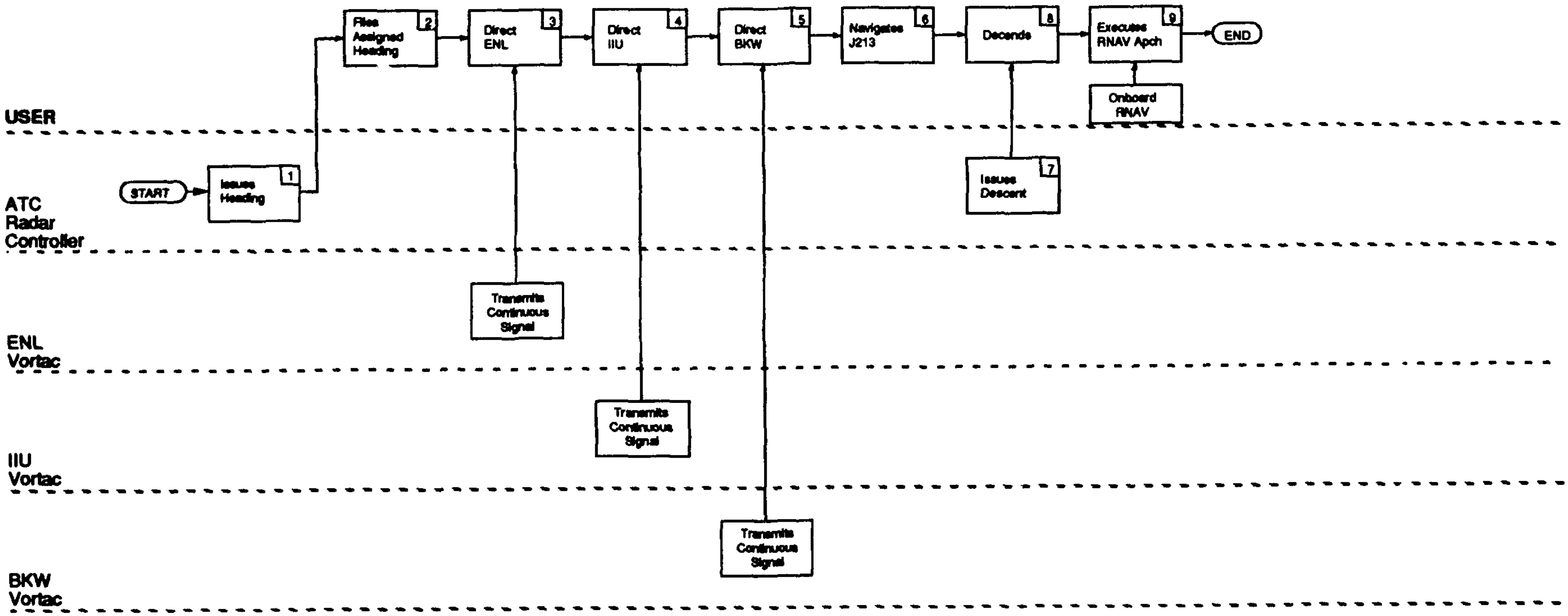

FIGURE 2-15
AREA NAVIGATION OPERATIONAL SCENARIO

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GLOSSARY

ACCURACY - The degree of conformance between the estimated or measured position and/or velocity of a platform at a given time and its true position or velocity. Radionavigation system accuracy is usually presented as a statistical measure of system error and is specified as:

a. Predictable - The accuracy of a position with respect to the geographic or geodetic coordinates of the Earth.

b. Repeatable - The accuracy with which a user can return to a position having coordinates which have been measured previously with the same navigation system.

c. Relative - The accuracy with which a user can measure position relative to that of another user of the same navigation system at the same time. This may be expressed also as a function of the distance between the two users. Relative accuracy may also refer to the accuracy with which a user can measure position relative to his own position in the recent past.

AIRCRAFT - Device/s that are used or intended to be used for flight in the air; when used in air traffic control terminology may include the flight crew.

AIR NAVIGATION FACILITY - Any facility used in, available for use in, or designated for use in, aid of air navigation, including landing areas, lights, any apparatus or equipment for disseminating weather information, for signaling, for radio-direction finding, or for radio or other electrical communication, and any other structure or mechanism having a similar purpose for guiding or controlling flight in the air or the landing and take-off of aircraft.

AIRPORT LIGHTING - Various lighting aids that may be installed on an airport. Types of airport lighting include:

1. Approach Light System (ALS) - An airport lighting facility which provides visual guidance to landing aircraft by radiating light beams in a directional pattern by which the pilot aligns the aircraft with the extended centerline of the runway on his final approach for landing. Condenser-Discharge Sequential Flashing Lights/Sequence Flashing Lights may be installed in conjunction with the ALS at some airports. Types of Approach Lights Systems are:

   a. ALSF-1 - Approach Light System with Sequence Flashing Lights in ILS CAT-I configuration.
   b. ALSF-2 - Approach Light System with Sequence Flashing Lights in ILS CAT-II configuration. The ALSF-2 may operate as an SSALR when weather conditions permit.
   c. SSALF - Simplified Short Approach Light System with Sequence Flashing Lights.
   d. SSALR - Simplified Short Approach Light System with Runway Alignment Indicator Lights.
   e. MALSF - Medium Intensity Approach Light System with Sequence Flashing Lights.
   f. MALSR - Medium Intensity Approach Light System with Runway Alignment Indicator Lights.
   g. LDIN - Sequence Flashing Lead-in Lights.

h. RAIL - Runway Alignment Indicator Lights (Sequenced Flashing Lights which are installed only in combination with other light systems.

i. ODALS - Omnidirectional Approach Lighting System consisting of seven omnidirectional flashing lights located in the approach area of a nonprecision runway.

2. Runway Lights/Runway Edge Lights - Lights having a prescribed angle of emission used to define the lateral limits of a runway. Runway lights are uniformly spaced at intervals of approximately 200 feet, and the intensity may be controlled or preset.

3. Touchdown Zone Lighting - Two rows of traverse light bars located symmetrically about the runway centerline normally at 100 foot intervals. The basic system extends 3,000 feet along the runway.

4. Runway Centerline Lighting - Flush centerline lights spaced at 50-foot intervals beginning 75 feet from the landing threshold and extending to within 75 feet of the opposite end of the runway.

5. Threshold Lights - Fixed green lights arranged symmetrically left and right of the runway centerline, identifying the runway threshold.

6. Runway End Identifier Lights (REIL) - Two synchronized flashing lights, one on each side of the runway threshold, which provide rapid and positive identification of the approach end of a particular runway.

7. Visual Approach Slope Indicator (VASI) - An airport lighting facility providing vertical visual approach slope guidance to aircraft during approach to landing by radiating a directional pattern of high intensity red and white focused light beams which indicate to the pilot that he is "on path" if he sees red/white, "above path" if white/white, and "below path" if red/red. Some airports serving large aircraft have three-bar VASIs which provide two visual glide paths to the same runway.

8. Boundary Lights - Lights defining the perimeter of an airport or landing area.

AIRPORT ROTATING BEACON - A visual NAVAID operated at many airports. At civil airports, alternating white and green flashes indicate the location of the airport. At military airports, the beacons flash alternately white and green, but are differentiated from civil beacons by dualpeaked (two quick) white flashes between the green flashes.

AIRPORT TRAFFIC CONTROL TOWER (ATCT) - A terminal facility that provides ATC services to aircraft operating in the vicinity of an airport or on the airport movement area. Authorizes aircraft to land or takeoff at the airport controlled by the tower or to transit the airport traffic area regardless of flight plan or weather conditions (IFR or VFR). A tower may also provide approach/departure control services.

AREA CONTROL FACILITY (ACF) - A facility established to provide air traffic control service to aircraft principally during the en route phase of flight.

AREA NAVIGATION (RNAV) - A method of navigation that permits aircraft operation on any desired course within the coverage of selected navigation signals or within the limits of a self-contained system capability. Random

area navigation routes are direct routes, based on area navigation capability, between waypoints defined in terms of latitude/longitude coordinates, degree/distance fixes, or offsets from published or established routes/airways at a specified distance and direction. The major types of equipment are:

1. VORTAC referenced or Course Line Computer (CLC) systems, which account for the greatest number of RNAV units in use. To function, the CLC must be within the service range of a VORTAC.

2. OMEGA/VLF, although two separate systems, can be considered as one operationally. A long-range navigation system based upon Very Low Frequency radio signals transmitted from a total of 17 stations worldwide.

3. Inertial (INS) systems, which are totally self-contained on the aircraft and requires no information from external references. They provide aircraft position and navigation information in response to signals resulting from inertial effects on components within the system.

4. LORAN-C is a long-range radio navigation system that uses ground waves transmitted at low frequency to provide user position information at ranges of 600 to 1,200 nautical miles at both en route and approach altitudes. The useable signal coverage areas are determined by the signal-to-noise ratio, the envelope-to-cycle difference, and the geometric relationship between the positions of the user and the transmitting stations.

AUTOMATED FLIGHT SERVICE STATION (AFSS) - Air traffic facilities which provide pilot briefing, en route communications, and VFR search and rescue services; assist lost aircraft and aircraft in emergency situations; relay ATC clearances; originate Notices to Airmen; broadcast aviation weather and NAS information; receive and process IFR flight plans; and monitor NAVAIDS. In addition, at selected locations AFSSs provide En Route Flight Advisor Service (Flight Watch), take weather observations, issue airport advisories, and advise Customs and Immigration of transborder flights.

COASTAL FIX - A navigation aid or intersection where an aircraft transitions between the domestic route structure and the oceanic route structure.

COMPASS LOCATOR - A low power, low or medium frequency (L/MF) radio beacon installed at the site of the outer or middle marker of an instrument landing system (ILS). It can be used for navigation at distances of approximately 15 miles or as authorized in the approach procedure.

1. Outer Compass Locator (LOM) - A compass locator installed at the site of the outer marker of an instrument landing system.

2. Middle Compass Locator (LMM) - A compass locator installed at the site of the middle marker of an instrument landing system.

CONTROLLED AIRSPACE - Airspace designated as a control zone, airport radar service area, terminal control area, transition area, control area, continental control area, and positive control area within which some or all aircraft may be subject to air traffic control.

DIRECTION FINDER (DF) - A radio receiver equipped with a directional sensing antenna used to take bearings to obtain a fix on an aircraft or by a pilot plotting the bearing indications of his DF on two separately located ground-based transmitters.

DISTANCE MEASURING EQUIPMENT (DME) - Equipment (airborne and ground) used to measure, in nautical miles, the slant range distance of an aircraft from the DME navigational aid.

DOMESTIC AIRSPACE - Airspace which overlies the continental land mass of the United States plus Hawaii and U.S. possessions. Domestic airspace extends to three (3) miles offshore.

EMERGENCY - A condition of being threatened by serious and/or imminent danger which requires immediate or timely assistance and action.

FLIGHT INFORMATION REGION - An airspace of defined dimensions within which Flight Information Service and Alerting Service are provided. Flight Information Service provides advice and information useful for the safe and efficient conduct of flight. Alerting Service notifies appropriate organizations regarding aircraft in need of search and rescue aid and to assist such organizations when required.

FLIGHT MANAGEMENT SYSTEM - A computer system that uses a large data base to allow routes to be preprogrammed and fed into the system by means of a data loader. The system is constantly updated with respect to position accuracy by reference to conventional navigation aids.

FLIGHT PLAN - Specified information relating to the intended flight of an aircraft that is filed orally or in writing with an ATC facility.

FLIGHT TECHNICAL ERROR - The accuracy with which the pilot controls the aircraft as measured by his success in causing the indicated aircraft position to match the indicated command or desired position on the display.

GLIDESLOPE - Provides vertical guidance for aircraft during approach and landing. The glideslope/glidepath is based on the following:

1. Electronic components emitting signals which provide vertical guidance by reference to airborne instruments during instrument approaches such as ILS/MLS, or

2. Visual ground aids, such as VASI, which provide vertical guidance for a VFR approach or for the visual portion of an instrument approach and landing.

3. Precision Approach Radar (PAR). Used by ATC to inform an aircraft making a PAR approach of its vertical position (elevation) relative to the decent profile.

INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO) - A specialized agency of the United Nations whose objective is to develop the principles and techniques of international air navigation and to foster planning and development of international civil air transport.

IFR AIRCRAFT/IFR FLIGHT - An aircraft conducting flight in accordance with instrument flight rules.

INERTIAL NAVIGATION SYSTEM (INS) - An RNAV system which is a form of self-contained navigation. (See Area Navigation/RNAV).

INSTRUMENT FLIGHT RULES (IFR) - Rules governing the procedures for conducting instrument flight. Also a term used by pilots and controllers to indicate type of flight plan.

INSTRUMENT LANDING SYSTEM (ILS) - A precision instrument approach system which normally consists of the following electronic components and visual aids:

1. Localizer - provides course guidance to the runway.

2. Glideslope - provides vertical guidance to touchdown.

3. Outer Marker - a marker beacon at or near the glideslope intercept altitude (4 to 7 miles from the runway threshold on the extended centerline of the runway.

4. Middle Marker - a marker beacon that defines a point along the glideslope at or near the point of decision height.

5. Approach Lights - airport lighting facilities that provide visual guidance to landing aircraft.

INSTRUMENT RUNWAY - A runway equipped with electronic and visual navigation aids for which a precision or nonprecision approach procedure having straight-in landing minimums has been approved.

LOCALIZER TYPE DIRECTIONAL AID (LDA) - A NAVAID used for nonprecision approaches with utility and accuracy comparable to a localizer but which is not a part of a complete ILS and is not aligned with the runway.

LONG RANGE NAVIGATION/LORAN - An electronic navigation system by which hyperbolic lines of position are determined by measuring the difference in the time of reception on synchronized pulse signals from two fixed transmitters.

MARKER BEACON - An electronic navigation facility transmitting a 75 Mhz vertical fan or boneshaped radiation pattern. Marker beacons are identified by their modulation frequency and keying code, and when received by compatible airborne equipment, indicate to the pilot, both aurally and visually, that he is passing over the facility.

MICROWAVE LANDING SYSTEM (MLS) - A precision instrument approach system operating in the microwave spectrum which normally consists of the following components:

1. Azimuth Station
2. Elevation Station
3. Precision Distance Measuring Equipment

MINIMUM NAVIGATION PERFORMANCE SPECIFICATION (MNPS) - A set of standards which require aircraft to have a minimum navigation performance capability in order to operate in MNPS designated airspace. In addition, aircraft must be certified by their State of Registry for MNPS operation.

MINIMUM NAVIGATION PERFORMANCE SPECIFICATIONS AIRSPACE (MNPSA) - Designated airspace in which MNPS procedures are applied between MNPS certified and equipped aircraft. Under certain conditions, non-MNPS aircraft can operate in MNPSA. However, standard oceanic separation minima is provided between the non-MNPS aircraft and other traffic. Currently, the only designated MNPSA is described as follows:

1. Between FL 275 and FL 400;

2. Between latitudes 27° N and the North Pole;

3. In the east, the eastern boundaries of the CTA's Santa Maria Oceanic, Shanwick Oceanic, and Reykjavik;

4. In the west, the western boundaries of CTA's Reykjavik and Gander Oceanic and New York Oceanic excluding the area west of 60° W and south of 38° N.

NATIONAL AIRSPACE SYSTEM (NAS) - The common network of U.S. airspace; air navigation facilities, equipment and services; airports or landing areas; aeronautical charts, information and services; rules, regulations and procedures, technical information, and manpower and material.

NAVIGATIONAL AID (NAVAID) - Any visual or electronic device airborne or on the surface which provides point-to-point guidance or position data to aircraft in flight.

NAVAID CLASSES - VOR, VORTAC, and TACAN aids are classed according to their operational use. The three classes of NAVAIDS are:

T - Terminal. From 1,000 feet above ground level (AGL) up to and including 12,000 feet AGL at radial distances out to 25 NM.

L - Low altitude. From 1,000 feet above ground level (AGL) up to and including 18,000 feet AGL at radial distances out to 40 NM.

H - High altitude. From 1,000 feet above ground level (AGL) up to and including 14,500 feet AGL at radial distances out to 40 NM. From 14,500 feet AGL up to and including 60,000 feet at a radial distances out to 100 NM. From 18,000 feet AGL up to and including 45,000 feet AGL at radial distances out to 130 NM.

NONPRECISION APPROACH - A standard instrument approach procedure in which no electronic glideslope is provided; e.g., VOR, TACAN, NDB, LOC, ASR, LDA, or SDF approaches.

OCEANIC AIRSPACE - Airspace over the oceans of the world, considered international airspace, where oceanic separation and procedures per the International Civil Aviation Organization are applied. Responsibility for the provisions of air traffic control service in this airspace is delegated to various countries based generally upon geographic proximity and the availability of the required resources.

OBSTRUCTION LIGHT - A light or a group of lights, usually red or white, frequently mounted on a surface or natural terrain to warn pilots of the presence of an obstruction.

OFFSHORE AIRSPACE - The airspace between the U.S. 3 mile limit and the oceanic CTA/FIR boundary.

OMEGA - An RNAV system designed for long-range navigation based upon ground-based electronic navigational aid signals.

PRECISION APPROACH PROCEDURE - A standard instrument approach procedure in which an electronic glideslope/glidepath is provided; e.g., ILS/MLS and PAR.

PROTECTED AIRSPACE - The airspace on either side of an oceanic route/track that is equal to one-half the lateral separation minimum except where reduction of protected airspace has been authorized.

RAIM - Receiver-autonomous-integrity monitoring determines the GPS integrity by comparing position fixes obtained from subset solutions (a four-satellite solution) of five or more satellites. The position fixes will then be compared with one another to determine if a satellite failure exists.

REMOTE AREAS - Sparsely populated areas such as mountains, swamps, and large bodies of water.

RHO-THETA COORDINATES - A coordinate system wherein the rho coordinate represents the slant-range distance from the aircraft to the VORTAC/DME/TACAN ground facility or an avionics computed waypoint (RNAV). The theta coordinate represents the bearing or direction to a fixed point.

ROUTE - A defined path, consisting of one or more courses in a horizontal plane, which aircraft traverse over the surface of the earth.

SIMPLIFIED DIRECTIONAL FACILITY (SDF) - A NAVAID used for nonprecision instrument approaches. The final approach course is similar to that of an ILS localizer except that the SDF course may be offset from the runway, generally not more than 3 degrees, and the course may be wider than the localizer, resulting in a lower degree of accuracy.

SLANT-RANGE - Direct distance from the aircraft to the VORTAC/DME/TACAN ground facility and not the actual horizontal distance.

SPECIALIST - The internal individual or group who provide service through the NAS (e.g., controllers, engineers, maintenance and management personnel).

TACTICAL AIR NAVIGATION (TACAN) - An ultra-high frequency electronic rho-theta air navigation aid which provides suitably equipped aircraft a continuous indication of bearing and distance to the TACAN station.

TERMINAL AREA - A general term used to describe airspace in which approach/ departure control service or airport traffic control service is provided.

TERMINAL-VERY HIGH FREQUENCY OMNIDIRECTIONAL RANGE STATION (TVOR) - A very high frequency terminal omnirange station located on or near an airport and used as an approach aid.

USER - The external individual or group that receive services from the NAS (e.g., Pilot, Air Carrier, General Aviation, Military, Law Enforcement Agencies).

VISUAL FLIGHT RULES (VFR) - Rules that govern the procedures for conducting flight under visual conditions.

ACRONYMS/ABBREVIATIONS

ACRONYM	MEANING
ACCC	Area Control Computer Complex
ACF	Area Control Facility
AFSS	Automated Flight Service Station
AGL	Above Ground Level
ALSF-2	Approach Light System with Sequence Flasher Model 2
ATC	Air Traffic Control
ATCT	Airport Traffic Control Tower
ATIS	Automatic Terminal Information Service
AVLORMON	LORAN-C Aviation Monitor
DF	Direction Finder
DME	Distance Measuring Equipment
DME/P	Precision Distance Measuring Equipment
DoD	Department of Defense
DOT	Department of Transportation
DUAT	Direct User Access Terminal
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FATO	Final Approach and Take Off area
FIR	Flight Information Region
FMS	Flight Management System
FSDPS	Flight Service Data Processing System
FSS	Flight Service Station
HALS	Heliport Approach Light System
HILS	Heliport Instrument Lighting System
HIRLS	High Intensity Runway Lights
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
INS	Inertial Navigation System
LDA	Localizer Type Directional Aid
LDIN	Lead-In Lighting System
LOM	Locator Outer Marker
LORAN-C	Long Range Navigation
MALSR	Medium Approach Light System with Runway Alignment Indicator Lights
MIRLS	Medium Intensity Runway Lights
MLS	Microwave Landing System
MNPS	Minimum Navigation Performance Specification
MSL	Mean Sea Level
MNPSA	Minimum Navigation Performance Specifications Airspace
NADIN	National Airspace Data Interchange Network
NAS	National Airspace System
NASSRS	National Airspace System-System Requirements Specification
NAVAIDS	Navigation Aids
NDB	Non Directional Beacon
NM	Nautical Mile

NOTAM	Notice to Airmen
ODALS	Omnidirectional Approach Light System
OMEGA	OMEGA
PAPI	Precision Approach Path Indicator
RCE	Remote Communication Equipment
REIL	Runway-End Identifier Lights
RML	Radar Microwave Link
RNAV	Area Navigation
RCLS	Runway Centerline Lights
RVR	Runway Visual Range
SFL	Sequenced Flashing Lights
SID	Standard Instrument Departure
STAR	Standard Arrival Routing
TACAN	Tactical Air Navigation
TBD	To Be Determined
TCCC	Tower Control Computer Complex
TCS	Tower Communications System
TDZL	Touchdown Zone Lighting
TLOF	Touchdown and Lift-off area
UHF	Ultra High Frequency
USCG	United States Coast Guard
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
VHF	Very High Frequency
VLF	Very Low Frequency
VOR	VHF Omni Range
VORTAC	VOR/TACAN
VOT	VHF Omnidirectional Range Test